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BOSTON, HOOSAC TUNNEL AND WESTERN RAILROAD COMPANY.

REPORT OF THE CORPORATORS,

APPOINTED UNDER ACTS OF 1874, CHAPTER 403.

JANUARY, 1875.

Ref.
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Commonwealth of Massachusetts.

The Corporators of the Boston, Hoosac Tunnel & Western Railroad Company, in compliance with the provisions of the Act under which they were appointed (Acts 1874, ch. 403), respectfully submit the following

REPORT:

Four members of the corporation had been appointed and qualified on the 29th of July, 1874, upon which day an organization was effected by the choice of William B. Washburn as President and of Stephen M. Crosby as Secretary of the company. To facilitate the despatch of business and to carry on more thoroughly the investigations ordered by the Legislature in the act of incorporation, two committees were at once appointed, one upon Contracts and Construction, consisting of Messrs. Washburn and Chadbourne; and the other, consisting of Messrs. Adams and Crosby, on Law Questions and Railroad Connections. Subsequently, to complete the number provided for by law, a fifth corporator was appointed, who gave to each of the two regular committees assistance in their work as frequently as occasion demanded.

Condition of the Property.

On the 6th and 7th of August the Corporators made an examination of all the property committed to their care. The Troy & Greenfield railroad from the Tunnel to Greenfield, operated under lease by the Fitchburg R. R. Co. as lessors of the Vermont & Massachusetts railroad, was found to be in an exceedingly unsatisfactory condition, which was due not only to defects in its original construction but to subsequent and continued neglect in the work of repairs,—the

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ties were decayed, the ditches filled up, and the iron worn out. Large claims were immediately made on the corporation by the lessees for aid, in addition to that provided for by the last Legislature (Resolves 1874, Chap. 67), to put the track in condition for trains to continue running upon it with safety during the autumn and winter. It was consequently evident that the road must at once be reconstructed or that extensive and costly repairs must immediately be made, a large proportion of which would prove a total loss to the State wherever a change of location might thereafter be decided upon. It was, therefore, deemed advisable to begin the work of reconstruction at once, and measures were immediately taken to secure the men and material necessary for a vigorous prosecution of the work. Mr. W. P. Granger was selected as chief engineer in charge of the operations, with Mr. Edwin Stratton as assistant engineer in the work of relocation. They were instructed to at once proceed with the preliminary surveys necessary to determine what changes in the line were desirable or feasible, so that the work might be put under contract and prosecuted as far as possible during the autumn.

RELOCATION.

To determine what alterations and improvements it was desirable for the State to make at this time,—how much of the old road was worth saving and how much was worthless,—was no easy task. Engineers and railroad experts had differed widely on this subject in the past, and they could not be expected to agree fully now. The Corporators, therefore, judged it advisable to select a consulting engineer, who had had wide experience in the location and construction of railroads, and to submit to him in a great measure the final settlement of the many difficult questions which were sure to arise. After careful inquiry and consideration, they secured the services of Mr. Thomas Doane, and he has been called upon to aid in settling all difficulties that have presented themselves to the mind of the resident engineer. His report in appendix C is referred to for a detailed account of the progress and present condition of the work.

After a careful examination of the possible changes, with due consideration of former surveys, it was judged best not to alter essentially the present location of the road, but to reduce curvature, where practicable so to do, and to make such other changes as would render the line first class when the work of construction was completed.

TRACK.

In the construction of bridges and all mason-work provision has been made for a double track, although a single track, of such thorough construction and of so easy a grade as has been arranged for, may be sufficient for some years to come; certainly until the western connections are secured and have had time to develop their importance. The additional work required for a second track can be done when such a track is called for, to better advantage than at present.

CONSTRUCTION WORK.

The changes to be made in the line between the Tunnel and Charlemont were substantially determined upon early in September, and the work was put under contract on the 15th of that month. The specifications required all bids to be made, both for earth-work and rock-work, per cubic yard. Of the five bids for this section that of N. C. Munson was the lowest, and he received the contract. This section was intended to be completed by the 1st of December, 1874, but, although now well under way, it cannot be completed before spring. On the 25th of September another contract was made for the remaining part of the road from Charlemont to Bardwell's Ferry, in two sections. The first section, from Charlemont to Shelburne Falls, was awarded to N. C. Munson, and the second section, from Shelburne Falls to Bardwell's Ferry, to B. N. Farren. The contracts for this work were made in the same manner as that for the first. Each section is to be completed by the 1st of July, 1875, and the work has been progressing in a satisfactory manner. As it was all contracted for by the cubic yard, at a specific price for each kind of work, wherever done, the Corporators were left free to change the location of the road as in the judgment of the engineers should seem best.

To secure the best and most durable track, especially on a road of so much curvature, it was apparent that steel rails would not only be the best, but by far the cheapest, as they could be purchased at a discount of about forty per cent. on their former price. A contract was accordingly made with the Pennsylvania Steel Company, for 1,100 tons of their best hammered steel rails, with the fish-joints and stops all complete. The rail weighs sixty pounds to the yard, and cost $85 per ton.

Where new bridges were needed, those of iron have been provided for; where the old ones would answer, they have been strengthened and made better than when first built.

Road West of Tunnel.

The road between the west portal of the Tunnel and North Adams was far from being completed, at the time of our appointment. Of the three bridges that were to have been completed by the 1st of August, not one was on the ground at the date of our first visit, August 7th. As this work was all under contract by action of the Governor and Council, we could only indirectly hasten its completion. We were able to begin to lay the track, Nov. 19th, and the last bridge was not yet in place at the time of the preparation of this report.

Road West of Adams.

That part of the road between North Adams and the Vermont line is still under the control of the Troy & Boston Railroad Co., and will be kept in running order by them until their lease expires. No work has been done upon it, but an examination has been made by the consulting engineer, and his report may be found in appendix C.

Work East of Bardwell's Ferry.

Although the work of construction authorized by chapter 402 of the acts of the last Legislature was confined to that part of the road west of Bardwell's Ferry, it was judged desirable that a survey should be made of the entire line. Mr. Stratton was therefore directed to make such survey under the following instructions:

"You are to be employed as engineer-in-chief, to make surveys of the Troy and Greenfield railroad east of Bardwell's Ferry, to determine the following points, viz:

"1. What changes are desirable if the present route is to be continued as the permanent through route.

"2. What changes can be made to have the through route pass through Greenfield.

"3. What is the best possible location for a through route for said road, east of Bardwell's Ferry, *the shortest route* and the *best grade, without any reference to local traffic.*"

In the prosecution of this work, he was authorized to procure all needed assistance, and for the results of his examinations and surveys reference is made to Mr. Doane's report in appendix D.

TUNNEL.

Under the construction given by the Attorney-General to the several acts of the last Legislature (appendix E), the appropriation for the completion of the Tunnel and for arching the same where necessary, was at the disposal of the Governor and Council, under whose direction the work was to be done, so that we, as Corporators, have had nothing to do with any contracts or work connected with the Tunnel, excepting to approve, at the request of the Governor and Council, the contract for arching made by them, and to appoint experts to examine and report upon the amount of arching necessary, as required by section 5 of the act (1874, chapter 403) under which the corporation was formed. That act is specific in defining the duties of the experts and in fixing the time for the examination. The experts selected as geologists were Professor T. Sterry Hunt, of Boston, and Professor James Hall, of Albany, N. Y.; as civil engineers, Thomas Doane, of Charlestown, Josiah Brown, of Fall River, and Daniel L. Harris, of Springfield.

The reports of these gentlemen are very full and will give a large amount of valuable information in regard to the present condition of the Tunnel, the amount of arching which will be required to render it safe for use, and the changes that may be expected through the action of agencies that are likely to continue in operation. It is a matter of regret that the work was so far from being completed when the examinations were made. Until the Tunnel is properly trimmed, there must be uncertainty as to the real condition of the rock. This unfinished condition of the Tunnel will explain, in part, the difference in the reports as to the amount of arching required, though the examination was delayed to the latest day possible, under the requirements of the law. For the reports of the experts, reference is made to appendix A. A tabulated statement has been made and printed with the reports, showing at a glance how much of the Tunnel is considered perfectly safe by all the examiners, how much all agree must be arched, and how much a majority agree should be arched.

In the same appendix will be found the report of E. S. Philbrick to the Governor and Council. Mr. Philbrick's intimate acquaintance with the Tunnel makes his report exceedingly valuable as a basis of comparison for these reports of the experts, who made their examinations separately, and, most of them, without any previous knowledge of the nature of the walls or condition of the work.

A final settlement under the contract for excavating the Tunnel was effected with the contractors by the Governor and Council on the 22d of December, and it was thereupon transferred to our control, subject to the contract for arching made with B. N. Farren shortly previous. The time required to complete this arching is estimated at from six to eight months; but provision is made in the contract for the daily running of two trains each way through the Tunnel while the work is going on, if found to be desirable. A single, iron-rail track will at once be laid through the Tunnel, and will be used by the contractors in doing the work of arching; trains will also be run over it, should it be deemed expedient to put them on.

FITCHBURG RAILROAD COMPANY.

It has already been stated that immediately after our appointment claims for aid in making repairs on the Troy & Greenfield road were made by the Fitchburg Railroad Co. These claims, we, as Corporators, did not feel authorized to allow, according to our interpretation of the lease under which that company holds the road. But, as something had to be done to keep the road in running order, it was agreed by both parties to leave the interpretation of the lease to William G. Russell, Esq., as referee. Both parties introduced witnesses, and made a full presentation of the case. The decision of the referee was, that the sleepers and iron put into the track between Greenfield and the Tunnel since July 1, 1874, and all sleepers and iron hereafter needed to render the road safe for operation, and the expense of placing the same, should be paid for by the State. Any unexpended balance of the fifteen thousand dollars appropriated by the last Legislature, which had not been expended in necessary repairs previous to July 1, was to be credited to the State as part payment for iron and sleepers used since that time. All other repairs are to be made by the Fitchburg Railroad Co. at its own expense.

Other Matters of Investigation.

The Corporators were further directed to furnish full and specific information to the Legislature on various points enumerated in detail in the second section of the act under which they were appointed. They were, also, by the fourth clause of that section, generally directed to give at this time such information, and to offer such suggestions and recommendations in regard to the management, development or disposition to be made of the railroad and Tunnel as they might deem expedient and for the interest of the Commonwealth. In presenting this part of the report, therefore, it will be most convenient to follow the line of investigation which has been pursued during the past summer; and, in doing this, it will be found that each of the several specific points upon which information has been called for will present itself for consideration in the proper place.

It does not seem expedient in the present report to enter into any disquisitions as to the peculiar geographical situation of New England or Massachusetts, as compared with other portions of the country, or as to the nature and industries of its people. These have certainly been sufficiently dilated upon heretofore, and it is now only necessary to maturely consider the existing facts immediately and practically bearing on the questions with which we have been called upon to deal. These questions relate wholly to the organization and development of a railroad undertaking; and before, therefore, attempting to pass upon them, it is necessary to have a very clear idea of what that undertaking may reasonably be expected to accomplish. If the Tunnel line is to be a mere duplicate Boston & Albany railroad, twenty miles farther north, running between the same termini and competing under a similar management for a share of the business supplied by the same feeders, in such case the questions of organization and management are greatly simplified. If, however, it is to become an agency towards the development of some new and larger system of transportation; if it is to introduce into the State more perfect facilities for carriage; if, in a word, it is ever to justify the enormous cost of its construction, then these questions of organization and development will probably be found far more intricate problems to deal with. The first investigation we had to enter upon related, therefore, to the new and especial uses to which the Tunnel line could be put now that it was practically completed. Was there any work of transportation for it to do which was not now done over the Boston & Albany road?—Was there any new element, or power, which it could introduce as a competing force, into the carrying business of New England?—These questions definitely settled, it would probably be found that subsequent details were almost in the nature of inevitable sequences from them.

Western Connections.

The Boston & Albany railroad forms a close connection at Albany with the western railroad system over the New York Central tracks. It is the most valuable outlet of the last-named company, and its relations with it are of the closest possible description. A rival line to the Boston & Albany, connecting with the Central road, might possibly enjoy equal and impartial advantages with it, but it could certainly expect no more; it would open no new channels of trade; it could introduce into New England no new elements of competition. Can, then, the Tunnel line, having at last reached the Hudson River, lead to any results which have not been brought about already?

A somewhat general survey of the channels of communication between the interior and the seaboard is necessary to any satisfactory solution of this question. Such a survey can, however, be made very brief. These channels of communication are of two descriptions—those by rail and those by water. Those by rail may best be considered first.

All-Rail Connections.

There are now four of these channels completed and in use, and yet others are in course of construction or projected. The completed lines are the New York Central, the Erie, the Pennsylvania, and the Baltimore & Ohio railroads. The projected lines are two in number: one following the south bank of the Mohawk River, and the other connecting Oswego, on Lake Ontario, with a point near the head-waters of the Hudson. One only of these several and competing lines is now brought into an all-rail connection with Massachusetts through the agency of the Boston & Albany road. The mission of the Tunnel should be to bring into the State as many of the others as possible; and the line operating through it should be organized and developed with that result kept steadily in view.

In order that the most definite possible information might be obtained as to what connections were feasible between the Tunnel line and these western routes, the Corporators placed themselves in direct personal communication with their leading officials, having interviews with Mr. Vanderbilt, President of the New York Central; with Mr. Ramsey, of the Albany & Susquehanna; with Mr. Dickson, of the Delaware & Hudson Canal Co.; with Mr. Jewett, of the Erie, who represented also in this connection the Baltimore & Ohio interest, and with Messrs. Scott and Cassatt, of the Pennsylvania railroad. It is believed that in this way we fully possessed ourselves of the views of each of these gentlemen and of the companies they represented.

The New York Central.

From Mr. Vanderbilt, both directly and indirectly, assurances were received that no discrimination whatever should be made by the Central road, as between the Boston &

Albany and Tunnel routes, but that both should receive every facility for the interchange of business and be treated with absolute impartiality. Mr. Vanderbilt took the ground that the New York Central railroad was purely a carrier for hire,—that the object of those controlling it was to make money, and that to do this they sought business from any and every quarter,—that it was wholly immaterial to them whence business came or whither it went, so that it came and went; and that now the New York Central was so equipped that it could easily accommodate any amount of traffic which might offer. As to any discrimination between the Tunnel and the Boston & Albany lines, Mr. Vanderbilt stated that the New York Central at its western terminus connected with two independent and competing roads, the Michigan Southern and the Great Western of Canada; both of these were always treated with impartiality, and he saw no reason why a different policy should be adopted towards roads connecting at the east end of the line from what was adopted at the west end.

These assurances seemed to be satisfactory so far as they went. But, even if they were carried out both in the letter and spirit, they could secure to the people of Massachusetts nothing that they did not already have,—nothing new could be anticipated from this quarter.

THE DELAWARE & HUDSON CANAL COMPANY, AND PENNSYLVANIA RAILROAD.

An interview was next had with Messrs. Ramsey, Dickson and Scott, looking to a connection with the lines represented by them,—one of which reached into the coal-fields of Pennsylvania, while the other composed the great central route to the West. The Albany & Susquehanna railroad, of which Mr. Ramsey is President, runs in a south-westerly direction from Albany and Schenectady to Binghamton, at which latter point it connects with the Erie railway and with the system of the Delaware & Hudson Canal Co., by which last corporation it has been leased in perpetuity. A close connection between this road and the Tunnel line could now be formed either at Schenectady or at Albany, by means of which a new access could be gained, not only to an additional railroad system to the West, but also to the coal-fields of Pennsylvania. Nor do the possible advantages of this connection stop here. Mr. Scott, President of the Pennsylvania Railroad Co., called the attention of the Board to the fact that a small link of only eighty miles of road, through a region rich in coal deposits and favorable to railroad construction, was alone required to effect a connection, over the Albany & Susquehanna, between the Tunnel line and the elaborate railroad system controlled by the Pennsylvania interest. The importance of such a connection cannot easily be overestimated,—it would at once throw into Massachusetts the great power and pervading influence of the Pennsylvania company as a competing force. When it is stated that this company now owns or controls 6,000 miles of track, leading to all points of the West, South, and Southwest, and representing $400,000,000 of capital,—that it is supplied with a most perfect machinery for transportation in competition with all other routes, and that its affairs are managed with unsurpassed skill and energy, an estimate may be formed of the consequences likely to ensue from placing it side by side with the existing transportation agency of Massachusetts. A considerable amount of information, as to the character and amount of business which might be expected from this connection, was prepared for the use of the Board at the direction of the Pennsylvania Railroad Co., and will be found in appendix B of this report. Both Mr. Dickson and Mr. Scott, on behalf of their respective corporations, evinced the utmost interest in the development of this connection, and for very obvious reasons,—in both cases it gave to them at least as much as it received from them. If they could open to it a close and valuable connection with the coal-fields and the interior; it, on the other hand, opened to them the shortest and most profitable access to the more densely populated regions of New England. The control of that New England business has hitherto been the greatest advantage which the New York Central road has enjoyed in the contest with its southern rivals;—the travel to and from New York city has always been subject to sharp competition, while that to Massachusetts has been an almost exclusive property. On behalf of the Pennsylvania road, Mr. Scott made no concealment of the great anxiety he felt to secure an outlet to that traffic, and expressed his readiness to enter into relations with the Tunnel line as close as those which exist between the Central road and the Boston & Albany, and to afford equally favorable rates between places in Massachusetts and all leading points at the South and West. An active railroad competition would thus be established, which, even if it does not permanently reduce rates, always produces an immediate influence on the manners of employés, and on the facility and despatch with which the work of transportation is effected. So far as the Delaware & Hudson Canal Co. is concerned, the mutual advantages and importance of this connection do not need to be enlarged upon,—they immediately suggest themselves. Not only would it open to that company an extended market for its coal, but it would convert the Albany & Susquehanna road, leased by it, from a local into a through line.

THE ERIE RAILWAY.

This, however, is but a portion of the large field which may be opened to the Tunnel line through this south-western connection, for at Binghamton the Erie railway also is reached. The Erie direction, as represented by Mr. Jewett, the President of the line, was found to be no less awake than Messrs. Dickson and Scott to the importance of the proposed connection. Here, too, assurances were given of arrangements for through business in no respect inferior to those existing between the Boston & Albany and the New York Central, which should go into effect as soon as the Tunnel was in condition to coöperate in them. Neither in this case, nor in that of the Delaware & Hudson Canal Co., was any delay called for to allow time for development; everything—roads, connections, rolling-stock, agencies and business—was ready, and the only difficulty lay at this end of the line. In the case of the Erie not a single link of the chain was wanting, and this fact was closely connected with the development of the Baltimore & Ohio combination. The recent completion of the air-line extension of that road to Chicago, makes practicable a new and close all-rail connection between that city and the seaboard. So far as all New York and eastern business is concerned, this extension is to be operated in connection with the Erie road, thus bringing it into communication with the Tunnel line.

RELATIVE LENGTH OF ROUTES.

As respects distance, an examination of the very elaborate tables in appendix B of the present report, will show that there is no material difference to all principal western points between the Boston & Albany in connection with the New York Central, and the Tunnel route in connection with the Albany & Susquehanna road.* On a front westward from Boston, extending from Chicago at the north to Pittsburg at the south-west, and including St. Louis, Louisville and Cincinnati, this difference would vary from 16 per cent. in favor of the newer route, to 22 per cent. in

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* The following table will show at a glance the comparative distances of the principal railroad points of the West from Boston by the New York Central and by the Albany and Susquehanna roads. The distance by way of the Boston & Albany and the New York Central is taken as the unit of comparison, and is given in the first column; that by way of the Erie railway and its connections, in the second column; that by way of the Northern Central, Philadelphia & Erie, Bald Eagle Valley & Pennsylvania roads, in the third column; that by way of the Northern Central and Philadelphia & Erie, in the fourth column; and that by way of the Northern Central, the Philadelphia & Erie, and the Low Grade Division of the Allegheny Valley roads in the fifth column. The last three routes are under the control of the Pennsylvania Railroad Co., and require the construction of some eighty miles of road by it, or by the Delaware & Hudson Canal Co., to complete the connection.

Comparative Table of Distances from Boston.

DESTINATION.	BOSTON & ALBANY.		BOSTON, HOOSAC TUNNEL & WESTERN.							
	Distance via N. Y. Cent. R. R. and connecting lines.	Percentage.	Distance via Erie Railway and connecting lines.	Percentage.	Distance via Northern Cent., P. & E., B. E. V. and P. Railroads and connecting lines.	Percentage.	Distance via Northern Central and Phil. & Erie Railoads and connecting lines.	Percentage.	Distance via Northern Cent., P. & E., L. G. Div. A. V. R. R. and connecting lines.	Percentage.
	Miles.		Miles.		Miles.		Miles.		Miles.	
Buffalo, . .	499	100	542	108	–	–	650	130	–	–
Erie, . .	527	100	630	107	–	–	679	116	–	–
Pittsburg, .	767	100	766	100	641	84	–	–	685	89
Cleveland, .	682	100	720	106	791	116	774	113	835	122
Toledo, . .	795	100	833	105	902	114	887	112	946	119
Chicago, . .	1,019	100	1,075	106	1,110	109	1,131	111	1,154	113
Columbus, .	820	100	858	105	834	102	912	111	878	107
Cincinnati, .	926	100	979	106	954	103	1,018	110	998	108
Louisville, .	1,036	100	1,089	105	1,064	103	1,128	109	1,108	107
Indianapolis, .	964	100	1,018	106	1,022	106	1,056	110	1,066	111
St. Louis, .	1,226	100	1,264	103	1,261	103	1,295	106	1,305	106

favor of the older, and would generally be from 3 to 5 per cent. only, to the leading railway centres of the West, in favor of the latter. Where such great distances are traversed, so small a percentage of differences between rival lines, especially in the carriage of freight, is found to be practically immaterial, and is, indeed, less than the difference (about 7 per cent.) which now exists between New York and Chicago by the three great competing lines—the Michigan Central, the Michigan Southern, and the Fort Wayne.

Relative Gradients of Routes.

As respects grades, the two routes, each considered as a whole, do not greatly differ,—the New York Central portion of the one possessing decided advantages over the Albany & Susquehanna section of the other, which again is in a great degree counterbalanced by the similar advantages of the Tunnel section in Massachusetts over the Boston & Albany. On the 340 miles from Binghamton to Boston, the total rise and fall is 3,688 feet on the Tunnel and Susquehanna route, as compared with 3,154 feet for an equal distance on the Albany and New York Central.* Under the *pro rata* system of carrying freights, however, the burden of unfavorable grades falls wholly upon the company which has to surmount them, and not upon the members generally of the combined line. In this case it would fall on the Albany & Susquehanna road,

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* *Boston, Hoosac Tunnel and Western Route.*

	Ascent Eastward.		Ascent Westward.	
Boston—Tunnel Summit,	1,521		2,339	
Tunnel Summit—Schenectady,	782		180	
Boston—Schenectady,		2,303		2,519
Schenectady—Binghamton,		1,385		1,951
Boston—Binghampton,		3,688		4,470

Boston and Albany.

	Ascent Eastward.	Ascent Westward.
Boston—Albany,	2,850	2,865
Albany, Westward 134 miles,	304	692
	3,154	3,557

and would be compensated for in very great degree in a reduced expense for power; its coal costing that company but $1.50 per ton, as compared with $4.00, its cost to the New York Central. So far as the Tunnel line itself, as an integral part of a through route, is concerned, it would have to contend with but 2,303 feet of adverse grade between Schenectady and Boston, as compared with 2,850 feet between Albany and the same point over the Boston & Albany.

Here, then, if it be but properly and promptly developed, and without need to go further, is an ample field through which the construction of the Tunnel may be justified. The projected lines and the facilities for water communication are yet, however, to be considered.

Projected All-Rail Lines.

The two most noticeable projected lines are those running, the one from some point near the head-waters of the Hudson to the port of Oswego on Lake Ontario; the other, from Albany west, along the south bank of the Mohawk, and parallel to the New York Central on its north bank. By means of the first of these two routes the Tunnel line, it is hoped, will reach the internal navigation of the great lakes in the first place, and can subsequently connect with the through railroad line already partially completed along the south shore of Lake Ontario. A great deal of information in regard to this route to Oswego will be found in the report of Mr. Morison, in appendix B, but the Board has not found it necessary to pass definitely upon its merits and advantages at this stage of the investigation. The road is, at best, one in the future, which must be further developed by those directly interested in it before it can practically be dealt with in connection with the Tunnel route. At present it needs to be regarded only as a possible element in future growth, a way to a connection with which should always be kept open. This scheme has, therefore, a very important bearing on the location of the Tunnel route from North Adams to a terminus in the State of New York, though not in itself sufficiently matured to call for immediate consideration. The same is true of the road on the south side of the Mohawk; it as yet exists only on paper, and, though those in charge of the Tunnel line should so shape its course that it may always be in a situation to avail itself of any new opening which may hereafter offer, it would be in the last degree reckless for them in any way to now involve the enterprise intrusted to their charge in the affairs of these inchoate companies. Such a proceeding would also seem to be wholly unnecessary in so far as the great question of securing access to the commerce of the lakes is concerned.

Eastern Terminus of Lake Navigation.

The eastern terminus of that navigation, so far as the Tunnel is concerned, would seem to be at Schenectady, rather than at Oswego. Schenectady, though 17 miles west of Albany, is but two miles further from Boston by the Tunnel route than Albany is by the Boston & Albany; in other words, to Schenectady, as a common point going west from Boston, the Tunnel line gains 15 miles over the Boston & Albany. Schenectady has the further advantage of being situated upon the Erie canal, immediately above the heavy lockage by which that canal descends along the falls of the Mohawk to the Hudson, above Albany. The canal navigation from Oswego to Schenectady is consequently of the most favorable description, presenting but 45 locks in a distance of 176 miles. The railroad to Oswego would be built more especially for the carriage of produce from the lakes to the seaboard. This same produce can now be carried by canal from Oswego to Schenectady, and there elevated from the barge into cars at a cost of $1.50 per ton. As the distance from Oswego to Ballston by either of the proposed routes is not less than 153 miles, the sum above named would allow a charge of but one cent per ton per mile upon them, at which rate it does not seem probable that, on a business open but half the year and unsustained by any considerable local traffic, they could compete. It is, therefore, not easy to see what advantage, so far as the transportation of western produce into New England is concerned, would be gained by placing the railroad terminus at Oswego instead of at Schenectady. Without undertaking, however, to finally pass upon this question, it is at least apparent that, while awaiting the development of the Lake Ontario enterprises, the Tunnel route can reach a terminus of lake navigation sufficient for every immediate purpose at a point which is already accessible to it. More detailed information on these points will be found in the report of Mr. Morison, in appendix B.

THE FIELD FOR DEVELOPMENT OPEN TO THE TUNNEL LINE.

From this general survey it would, therefore, appear that the field open for development in the interests of the people of Massachusetts through the Tunnel line, as distinct from that hitherto developed by the Boston & Albany, is of the most ample description. Leaving the New York Central wholly out of the question,—treating it as if it did not exist,—the connections ready for immediate use include both land and water routes stretching to every part of the interior and capable of placing the Tunnel line at once, so far as through business is concerned, on a footing in no respect inferior to that of the Boston & Albany. Through the agency of the Tunnel route, if properly and energetically managed, eight or ten thousand miles of track and hundreds of millions of additional capital may be brought to bear as a competing force to do the transportation of Massachusetts. No construction of long or expensive new lines is called for,—no loans of credit to aid in the building of projected roads of dubious value is required to secure this important result; it is only necessary to take advantage of facilities which already exist and which invite participation.

WESTERN TERMINUS OF TUNNEL LINE.

If these premises are sound, certain conclusions will be found to result from them which render it no less unnecessary than inexpedient for the members of this Board to now undertake to pass upon the relative merits of the several points suggested as being best adapted for the terminus of the Tunnel line in New York, or as to the best route by which such point could be reached. As such terminus, Troy, Albany and Schenectady each have earnest advocates, prepared to show that every possible merit is concentrated in the particular locality favored by them, and in their especial route to reach it. The investigations which have been made are sufficient to induce us to conclude, that, when this question presents itself at the proper time, its decision by those who may then have the interests of the line in charge will be found very simple; that it will, in fact, be practically dictated by circumstances over which they will have very little control. At present it is sufficient to say that two routes to Albany as the terminal point have been pressed upon our consideration, —that one route already exists to Troy, and that another is projected to Schenectady. There is, therefore, no probability that the Tunnel line will lack western outlets, or that those controlling any of these outlets will prove unwilling to negotiate in respect to their use. For us to undertake at this time publicly to decide upon their merits would merely provoke a bitter and wholly useless struggle before the Legislature, which could not but endanger the passage of any measure of practical utility, and greatly embarrass those negotiations which must hereafter inevitably be entered upon. An easy access to Albany, to Troy or to Schenectady, as hereafter may be desired, is perfectly feasible at reasonable cost; to further discuss the subject now would inevitably complicate rather than simplify matters.

Organization of the Tunnel Line.

With this ample field for usefulness before it, the question next presents itself,—How can the Tunnel line be organized so as to secure the greatest results from it? On this point, as the result of our investigations, the members of the Board, regardless of all former individual predilections, have found themselves compelled to very definite conclusions, as a unit. It will be noticed that the inevitable connections of this line —the connections through which alone, for years to come, it can hope to be of any real service to the people of the State—must be with large consolidated interests, doing an enormous business under vigorous and concentrated managements. It will also be noticed that it is the destiny of the Tunnel route to live in active competition with a rival route immediately south of it, and that this rival route is in the hands of a firmly consolidated corporation of large means, which carries on an enormous business by means of a very perfect equipment, controlled by a vigorous and experienced management. To justify the construction of the Tunnel, it is necessary that a very extensive traffic should be carried on through it at very low rates. Here, then, are three conditions to success,—a vigorous and powerful connection, a formidable and incessant competition, and a heavy individual traffic. Now, if there is one principle more clearly established than any other, as a result of all railroad experience, it is that disconnected corporations, under a loose or feeble management, and with insufficient capital and equipment, can neither deal successfully with connecting, nor struggle successfully against competing, roads. So, also, as regards railroad business, it is only when it is done on the most extensive scale that it can be done on the most favorable terms; that it may be done economically, the volume of business must be the largest possible, and the machinery for handling it the most perfect possible. These principles are very elementary, but they are apparently conclusive as to the matter under discussion; for we hold it almost puerile to hope that the Tunnel route can be developed in any such way as to justify its construction except through the agency of an energetic, concentrated and wealthy management. In organizing such a management, it may be desirable to secure every guarantee of the use of the Tunnel by weaker connecting roads; but it is none the less true that the business of the main through line can only be developed—as the people of the State have a right to expect it should be developed—through a management as vigorous as those with which it is forced either to contract or to contend. A large business cannot be done by a small or poor company.

PROPOSED METHODS OF ORGANIZATION.

Four methods of organization have been suggested. These are,—first, the simple possession of the Tunnel and some portions of the connecting roads by the State, with a view to holding it in trust, charging simply a moderate toll for its use; this being the plan known as the "Toll-Gate Plan."

THE "TOLL-GATE" PLAN.

We do not consider it necessary to discuss this scheme in detail. It is perfectly feasible for the State to hold the Tunnel in this way; but we are wholly unable to see what public good would be subserved thereby, unless the State also held the road on each side of the Tunnel to the point at which it is intersected by the most remote connecting road. For instance, it is not easy to see how the fact of the Commonwealth owning the Tunnel could protect or benefit the Boston, Barre & Gardner, or the Boston, Clinton & Fitchburg roads in the use of the Tunnel, unless the Commonwealth controlled the road east and west of that locality to the points where these roads intersected with the through line, and to the points on the other side where they proposed to leave it. This proposition, also, is based upon what we cannot but regard—for the reasons which have already been given—as the mistaken assumption that disconnected companies of small capital, and necessarily feeble management, can effectively develop the traffic of great through lines.

Ordinary Corporate Management.

The sale of the Tunnel to a private organization has also been suggested as a solution of the difficulty, and provision for it was at one time made by law. As the Legislature, in framing the act creating this corporation, especially struck out of the bill a provision directing inquiry to be made on this point, it is unnecessary to further discuss it. As only through its sale could the Tunnel be placed under private management, this exclusion of the proposal of sale involves also the exclusion of a recourse to ordinary corporate management.

Exclusive State Ownership.

Under these circumstances, the only other forms of management which can be suggested are state-ownership, pure and simple, on the one side, and, on the other, a system of mixed ownership, in which the property of the State would be consolidated with that of those owning the other links which go to make up the through line. From our present point of view, the project of exclusive state-ownership ceases to be a theoretical question and becomes a purely practical one. Looking upon it simply as such,—carefully excluding from its consideration all differences of opinion as to its economical, social and political bearings,—we have been unable to arrive at a divided conclusion. Such a solution of the difficulty is practically out of the question, and, at this time, not to be thought of. The financial issue alone would seem to present an insuperable obstacle, for it is highly improbable that the people of the State would consent to even the lowest expenditure which it would necessarily involve. How much this would amount to cannot now be definitely stated; the sum could not, however, but be very large, involving, as it must, in the first place, the purchase, at the outside price, of the connecting roads necessary to complete the through line; and, secondly, their development and equipment when purchased. For if the people of the Commonwealth for a moment imagine that, having now driven a tunnel through the Hoosac Mountain, and, having thus secured an unbroken line of rails from Boston through to the West,—if they imagine that, having secured this result, they have a through line, equal to the doing of a first-class business, they are laboring under a most unfortunate misapprehension, of which it would be well to at once disabuse them. Very large sums, the amount of which cannot now be readily estimated, are yet to be expended before the line from Boston to North Adams, or even to Greenfield, can be made ready to do any considerable traffic, or to do it with any economy. To compete over this line, in its present condition, with the Boston & Albany road would be simply out of the question. Through considerable distances it is now, at best, but a second-class single-track road, with an insufficient equipment, without proper terminal facilities, and clad only with iron. It is probably, therefore, no overestimate to say that, at this time, were the rails connected through from Boston to Troy, many millions of additional outlay would yet be required to place the whole road in any condition to do a large business economically; while the mere attempt to do such a business under existing circumstances, were such an attempt feasible, would, in less than six months, utterly demolish considerable sections of the line. If these facts are once fully understood, it is not probable that, in the present divided state of public opinion on the subject of the state-ownership of railroads, the people of Massachusetts would, in addition to the $14,000,000 the Tunnel has already cost, authorize an additional outlay of some $20,000,000 in round numbers more for the purchase and development of the roads connected with it. As a practical legislative measure, therefore, the complete ownership by the State of the entire line seems to us to be beyond the range of discussion. Not only would it involve an unknown expenditure of public money,—for which we do not believe that either the Legislature or the people are prepared, and which certainly none of us are prepared to advocate,—but it is also wholly inconsistent with that early separation of the finances of the Tunnel railroad from those of the State, which we believe to be dictated by every consideration of prudence.

Mixed Ownership and Management.

If no one of the three methods of organizing an effective management, which have now been considered, is admissible, there only remains the one other,—that resulting from a mixed ownership,—to which we are necessarily brought. Under this system, the properties of the State would be consolidated with those of the private companies, and the whole would be managed by a board of directors representing the two constituencies. This seems to be the only practical solution of the difficulties which now impede the development of the Tunnel route, and the effecting of an organization of the nature referred to is apparently the essential step now to be considered.

Legal Rights of Commonwealth.

The act (1874, chapter 403) under which the present corporation was organized, directed it to submit full and specific information to the present Legislature on various points relating to the rights of the Commonwealth touching the several corporations owning the roads by means of of which a through line to the West, by way of the Tunnel, might be organized. The information called for related to three different matters: first, to the voluntary consolidations which the corporations owning the properties might be disposed to favor; second, to the power of the State to take possession of the properties of these corporations, under the reserved right known as the 10 per cent. purchase clause; and, third, as to the purport and binding force of any traffic contracts which may have been entered into between the State and any corporation or corporations owning or controlling railroads having connections with the Tunnel. So far as the information thus called for involves legal considerations, we would respectfully refer to a statement and opinion of James C. Davis, Esq., printed in appendix F, to this report; which opinion has also been examined and revised by Hon. E. R. Hoar. To that document we do not deem it necessary to add any suggestions of our own. The practical, as distinguished from the legal aspect of the question, is of more consequence, and to that we propose to address ourselves.

THE END TO BE KEPT IN VIEW.

Unless our investigations have resulted in wholly erroneous conclusions, the practical end to be kept in view is, as we have already stated, the organization, under one vigorous management, of a through railroad line between eastern Massachusetts and the interior of the continent. In effecting this, also, the State should be involved in the least possible future outlay, and the earliest practicable separation between its finances and those of the corporation should be effected. These results can be brought about in either of two ways: the corporations may voluntarily consent to the necessary consolidation of interests, merging themselves in it, or they can part with their properties, as the result of either compulsion or negotiation, and the State can then dispose of a proportional interest in the consolidated lines to new associates, in this way relieving itself of an undue financial burden. Those holding the interest thus disposed of, would then constitute the element of private ownership in the new organization, in lieu of the original holders of the property.

THE ASSUMPTION OF CONNECTING ROADS BY THE STATE.

The right of the Commonwealth is unquestioned to assume any or all of the properties required to complete the desired through line, on replacing to the owners the capital originally paid in, together with an amount equal to ten per cent. per annum on such sum from the date of its investment, after deducting the dividends received upon it. This right, however, is of very doubtful value, as, in order to avail itself of it, the Commonwealth would now have to pay, in the case of the Fitchburg road, $192 each, for shares which are selling in the market at $121; and, in the case of the Vermont & Massachusetts road, $312 each, for shares which have in the market never touched their par value, and are now selling freely at $85. There can, also, in view of the opinion upon that point of Judge Hoar (appendix F) be little doubt, that the Commonwealth would have a right to assume possession of the properties of these corporations under its right of eminent domain, subject to the payment of compensation therefor; but this proceeding, if resisted, would involve so much litigation, and would entail a financial liability so difficult to estimate in advance, that it is unlikely to be resorted to. In any event, recourse would naturally be had to either of these ways of effecting the desired consolidation, only after every effort through negotiation had failed. The first attempt, therefore, must necessarily be through negotiations. These must, apparently, be conducted with the representatives of either the Fitchburg or of the Massachusetts Central Railroad Companies, or with both,—for these two alone control routes which, in combination with the Troy & Greenfield road, could complete a through line,—leaving the portion of the route west of the Tunnel to be decided upon after the eastern division has assumed a definite shape.

Negotiating with Connecting Roads.

Acting under instructions (Acts 1874, chap. 403, § 2, clause 1) to ascertain what combinations or consolidations to include the corporations referred to could be effected, the Corporators had various interviews with the officials of those companies. So far as anything specific or particular was concerned, these interviews were necessarily very unsatisfactory. Neither party had any authority to conclude anything, and, until each could know what the other was prepared to offer or accept, neither could be expected to commit itself. The conversations were, therefore, simply confined to generalities. We are, however, able to state that the representatives of the corporations expressed the most perfect willingness to negotiate, on terms which impressed this Board as not unreasonable, for either the sale, the lease, or the consolidation of their properties; they simply desired that some one should be authorized to negotiate with them. The only reservation intimated as likely to be insisted upon, related in the case of the Fitchburg road to a guarantee of a reasonable rate of dividend to the stockholders of the company; this conceded, the officials in question expressed a confident belief that the corporation would be found disposed to meet the Commonwealth with satisfactory terms.

Conclusions.

In view of all these facts the members of this Board have arrived at certain very simple and definite conclusions as to the steps immediately to be taken in relation to the Tunnel route, and these conclusions they have embodied in a form of bill, which accompanies this report. To these conclusions they have, one and all, found themselves compelled by the logic of their investigations, regardless of preconceived theories. As regards the Tunnel line itself, the previous estimates we had formed of the extent of the work it might be made to do, and of the public advantages which, under a vigorous management, might be made to result from it, have been much increased as our work progressed. We are, however, at least equally impressed with the extreme necessity of some early action which shall fix a policy under which it may be developed. The line is now in a position of no little jeopardy, and subject to contingencies which may greatly hamper its future growth. As yet, however, no united through line exists, nor is it even clear that the Legislature proposes to authorize one; the act from which this Board derived such power as it has, by the provisions of its seventh section, indeed, especially forbade any action on its part of a permanent character. Under these circumstances, we feel it incumbent upon us to urge upon the Legislature a decisive course looking to the organization of such a through line as may secure to the people of the State a fair prospect of developing the capabilities of the route. To that end we offer a bill of the simplest possible description, which, while it involves no new appropriation of public money, presents for an early decision the single issue of a consolidated line under mixed ownership. No attempt is made to insert in this measure multifarious and complicated provisions regulating points of detail in advance. We do not believe that it is practicable to thus decide these questions, or that it is desirable for the State, any more than for private individuals, to fetter and tie down its agents by public conditions, as they are about to enter upon a difficult negotiation. If the Commonwealth cannot trust its servants, it may rest assured it can never successfully take a part in the management of a railroad property. In that case, the Tunnel had best be sold at once, that it may have a chance of future usefulness in the hands of private corporations who have more confidence in their agents. It is very certain that the great mass of questions and issues can only be settled as they arise, and then by persons clothed with ample power to settle them, and responsible for the use of that power ;—it is as wholly futile to try to regulate and tie up the details of a railroad enterprise in advance, as it would be to order the succession of events.

The bill we submit, therefore, looks only to the organization of a corporation, with an element of permanence in it, the first duty of which shall be to effect a consolidation of interests. This done, we believe that other questions must be left to be disposed of as they arise. The great Tunnel route is unlikely either to be completed in a day, or perfected by a single act of legislature. The details of this bill call for little explanation. Provision is made for a new selection of directors in place of the present corporators, for obvious reasons, and the terms during which these directors shall hold office are graduated with a view to securing permanence of management and cutting off in so far as possible the liability to any general change for political reasons. Two clauses only regulating details in any measure for consolidation which may result from the passage of this bill are inserted, both of which explain themselves ; the one secures to the Commonwealth in any consolidated company a representation not less than that of all the private owners combined, and the other provides for the impartial use of the Tunnel line by all railroads connecting with it. These it is believed are cardinal points, demanded by public opinion, and which may properly be laid down in advance of any negotiation. The bill further provides that no consolidation of interests shall take effect until its terms have been formally approved by the Governor and Council,—in other words, the Governor and Council are placed towards the State's directors in the same position in which the body of stockholders in the private corporation stand towards the ordinary board of directors. The Governor and Council were designated for this purpose, rather than the Legislature itself, for the very obvious reason that the Legislature is in session on an average much less than half of the year, and, upon questions affecting railroad interests, prompt action is usually advisable. Beyond this it is believed that no further explanation is requisite, either of the measure submitted, or of the reasons which led to its preparation. The reasons have been stated at length. The measure is based upon the simple, familiar principles, which have long and universally regulated all corporate action. A board of directors is authorized to take certain steps deemed essential to the success of the common enterprise, and the result of their action is subjected to the approval of those who, for that purpose, represent the owners of the property.

WM. B. WASHBURN,
CHAS. F. ADAMS, Jr.,
P. A. CHADBOURNE,
S. M. CROSBY,
S. B. STEBBINS,
Corporators.

AN ACT

IN RELATION TO THE BOSTON, HOOSAC TUNNEL AND WESTERN RAILROAD COMPANY.

Be it enacted, &c., as follows:

SECT. 1. The governor, with the consent of the council, shall, as soon as practicable after the passage of this act, appoint five persons to be directors of the Boston, Hoosac Tunnel and Western Railroad Company; and whenever three or more of the persons so appointed shall have been qualified, the commissions of the corporators appointed under chapter four hundred and three of the acts of the year one thousand eight hundred and seventy-four, shall be vacated. One of the persons so appointed shall hold his office for five years, one for four years, one for three years, one for two years, and one for one year from the first day of July next after the passage of this act; and before the first day of July in each year thereafter, one director shall be appointed for the term of five years. Upon the occurrence of any vacancy before the expiration of a term, an appointment shall be made for the residue of such term.

SECT. 2. The board of directors provided for in the preceding section shall be a body corporate and shall have all the powers and be subject to all the duties and liabilities of boards of directors of railroad corporations, under the laws which now are or hereafter may be in force, except in so far as the same may be inconsistent with the provisions of this act, or of future acts passed in amendment hereof; *provided*, that wherever, under the laws of this Commonwealth, any act of the board of directors of a railroad corporation has to be submitted to the body of stockholders thereof for their action, in every such case the acts of the directors of the Boston, Hoosac Tunnel and Western Railroad Company shall, before taking effect, be subject to the approval of the governor and council; and in case of any consolidation of properties, as hereinafter provided for, the acts of the board of directors of the consolidated corporation shall, in the cases above specified, be subject to the action of the body of its stockholders, and also of the governor and council.

SECT. 3. Immediately upon the organization of the board of directors, provided for in the first section of this act, all the rights and property of the State in the Southern Vermont Railroad, in the Troy and Greenfield Railroad, and in the Hoosac Tunnel, shall be transferred into their charge; and they shall have full and exclusive authority over, and be accountable for, all unexpended moneys which have been appropriated for the construction or completion of said railroads and tunnel. The said board of directors shall thereupon replace all other authorities, and shall represent the Commonwealth in every transaction affecting said railroads and tunnel, or arising out of any agreements or contracts now in force relating to the same.

Sect. 4. The board of directors provided for in section one of this act shall, as soon as practicable after entering upon their duties, proceed to negotiate with the corporations owning or operating railroads forming parts of a through railroad line between a point or points in eastern Massachusetts and points in the eastern part of the State of New York, by way of the Hoosac Tunnel, with a view to the early consolidation of such roads under one management.

Sect. 5. The directors of the Boston, Hoosac Tunnel and Western Railroad Company are hereby authorized to consolidate and unite the franchises and properties by this act placed in their charge, with the franchises and properties of other corporations forming parts of a through line, as provided in the preceding section, or, if necessary, to lease the same if beyond the limits of the State, upon such terms as may be agreed upon, subject always to the ratification and approval of the governor and council, and also of the stockholders of any private corporation concerned, at a meeting called for the purpose; *provided*, that the name of such consolidated corporation shall be the Boston, Hoosac Tunnel and Western Railroad Company, and provided also, that its entire capital stock, and bonded and other indebtedness shall not at the time of consolidation exceed millions of dollars.

Sect. 6. The board of directors of any consolidated corporation organized under the provisions of this act, shall have all the powers and be subject to all the duties and liabilities of boards of directors of railroad corporations, and shall consist of eleven persons, of whom the directors appointed under the first section of this act shall be five, and five shall be chosen by the stockholders of such corporation, at a meeting to be held within thirty days after the final approval of the consolidation; and said last-mentioned five directors shall be chosen to hold office for similar terms and under the same conditions, so far as may be, as the directors appointed under the first section of this act. The ten person selected in the manner aforesaid, or a majority of them, shall forthwith proceed to elect a president of the corporation, who shall hold such office at the pleasure of the board of directors, and shall be, *ex officio*, a member thereof; and should the person so chosen as president be at the time of such a choice a member of said board of directors, his acceptance of such office shall create a vacancy in said board, which shall thereupon be filled by appointment or election, as the case may be.

SECT. 7. In any consolidation which may be effected under this act, the right shall be forever secured to every railroad corporation, whose tracks connect with such consolidated line, to have persons or property coming to or going from such connecting road carried over the whole or any part of the consolidated line, on terms as favorable as the corporation operating said line carries its own passengers and freight of similar description; and, in case of an inability to agree as to what such terms are, the question may be decided on the petition of either party in the manner provided in sections one hundred and sixty-six and one hundred and sixty-seven of chapter three hundred and seventy-two of the acts of the year one thousand eight hundred and seventy-four.

SECT. 8. Section seven of chapter four hundred and three of the acts of the year one thousand eight hundred and seventy-four, and all other acts and parts of acts inconsistent herewith, are hereby repealed.

SECT. 9. This act shall take effect upon its passage.

APPENDIX.

[A.]

REPORTS OF EXPERTS.

REPORT OF JAMES HALL.

ALBANY, October 10, 1874.

PRESIDENT P. A. CHADBOURNE:

DEAR SIR:—On the 24th day of September last, I received from you a communication, of which I have appended a copy. In accordance with your instructions, I proceeded, on the 28th day of September, to the Hoosac Tunnel, and reporting myself to B. D. Frost, Esquire, the State Engineer, I was furnished with the necessary assistance and means of exploring the Tunnel, and commenced the work.

The first point of inquiry in your instructions relates to "the kind of rock and dip of strata through the entire Tunnel."

At the western entrance, the rock is a micaceous gneiss, or coarse decaying mica-slate, resting against or upon grayish white-banded limestone, which appears in the cutting as we approach the portal. This micaceous slate, with the exception of some harder layers, is everywhere in a state of decay or decomposition; and the Tunnel, for the whole distance of 2,200 feet, is already arched with brick, to protect the sides and roof. It is, therefore, only possible to see the rock in the piles of materials brought out from the excavation at the west end; and from these, together with some slight exposures remaining, we learn that the rock consists of a coarse, distinctly laminated, micaceous gneiss, or coarse mica-schist, in a decomposing condition, and colored by iron. This rock alternates with stronger beds, and less distinctly laminated, and which have resisted decomposition both *in situ* and in the exposed mass brought out from the Tunnel. At a point some 1,200 or 1,400 feet from the west portal, a bed of coarse, impure brown hematite was cut through in the progress of the work. This ore-bed is still visible, cropping out near the line of the road from the Tunnel to the west shaft, and has a thickness of from four to six feet.

From the termination of the arch to about 3,900 (4,000) feet, we have mica-schist and micaceous gneiss, with alternations of coarser and finer beds. Between 3,500 and 4,000 feet, a gradual change takes place,—the beds become coarser and stronger, and the fracture more silicious. The mica-slate, or mica-schist, passes, by gradations, to quartzite, with seams of mica and sometimes some hornblende, while some of the intervening beds have the character of compact gneiss. The more silicious beds are often traversed by seams of calcite, with also some veins or seams of decomposing feldspar and soft slaty matter.

The hard, silicious beds continue to about 6,000 feet, beyond which there are alternations of a gneissoid character; and between 6,250 and 6,400 feet the whole gradually passes into a granitoid gneiss, which becomes less and less micaceous, till the rock assumes a coarse crystalline character. At about station 10,000, there is a mass of epidotic rock, consisting of epidote and crystals of feldspar, having a thickness of about fifty feet. At 10,250 feet, the rock is soft, as if from partial decomposition; and near 10,500, masses of epidote rock are intercalated or interstratified with the granitoid rock. This now becomes gradually more gneissoid, and there are apparently some alternations of micaceous beds towards the east, precisely as on the west side of the same rock. Between 10,500 and 10,800 feet, there are some silicious beds, and also conglomeratic; and the granitoid gneiss recurs again after passing station 11,000.

Near the central shaft there is a silvery mica-schist, some portions of which are quite soft, and contain garnets. It is the same rock through which the central shaft has been sunk.

From the central shaft, eastward, the prevailing rock is soft mica-schist, the beds sometimes more micaceous, and at a few points, harder and more silicious. The rock has a gentle dip to the eastward. There are frequent slight alternations in quality and texture of rock in passing towards the eastern end of the Tunnel, and the strata generally become more fissile, and softer; so much so, that the rock on the eastern face of the mountain has been termed a talcose slate.

In both the eastern and the western divisons, the rock is traversed by quartz seams, sometimes not more than an inch in thickness, but frequently several inches, and, in a few examples, from one to two feet; and one seam is more than four feet in width for a portion of the distance exposed. The beds are likewise traversed by seams of decomposing feldspar, accompanied by soft shaly matter; and these are more common where there has been a slipping of the strata along a seam or joint. The quartz seams are usually more firm, though not unfrequently accompanied by soft, decomposing material. Reference will be made to these seams in another part of the Report.

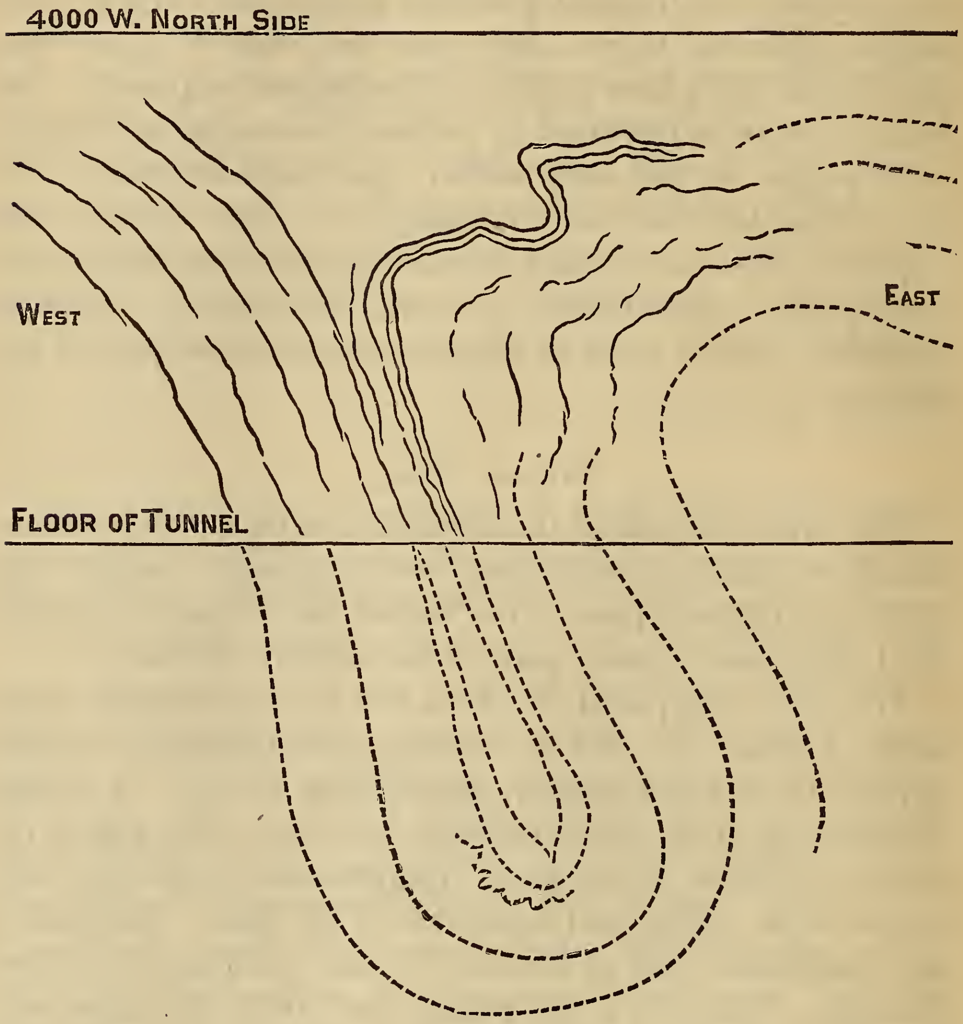
DIP OF STRATA.

The strata throughout the mountain, so far as can be determined by many observations, have a general easterly dip, varying in different parts of the Tunnel, and subject to extreme local variations in many parts of the western division.

From the west portal the beds dip to the eastward at an angle of about 45°, and at several points farther on, the dip appears to be much greater, approaching to 60°. A critical examination of the rocks, between 3,000 and 5,000 feet in the western division, shows great irregularities in the dip, with considerable folding and contortion in the beds. The rate of dip sometimes falls as low as 20°, and even less for short distances; while, in a few points, the strata are apparently quite horizontal. These conditions, however, I conceive to be only of local extent, and such irregularities do not affect the general conclusions regarding the easterly dip of the strata forming the entire mountain.

These minor foldings, which may even give reverse dips for short distances, are due to the action which has elevated the westerly side of the mountain, or depressed the central portion, and this has resulted in the folding and partial crushing of some of the intermediate parts.

To work out carefully these local changes of dip and the foldings would require much time. A single one of these examples is given on the next page—the continuous lines showing what is visible in the section, and the dotted lines representing the probable continuation of the beds below the floor of the Tunnel.



As a rule, the high dips continue throughout the granitic beds, gradually declining towards the central shaft. Going eastward from the central shaft, the dips are low, varying in some parts from 15° to 20°. These low dips are due to gentle undulations of the strata, and not to any pressure or crushing, as in the western division. The dip of the beds gradually increases, till at 9,900 it is about 40°, afterwards becoming about 70°, which is the prevailing rate of dip for the greater part of the distance to the eastern portal.

There is much greater regularity in the character of strata and of dip in the eastern division than in the western; and the first thousand feet from the eastern portal present no points of irregularity in dip or condition of beds.

As regards "the probable effect of the agencies now in operation, or that are likely to be in operation, in changing the character of the rock, or in any way affecting the safety of the Tunnel," we may note the following conditions.

You have removed from the mountain solid materials which filled a space of 20×24 feet in height and breadth, and for a length of nearly five miles; essentially twelve millions of cubic feet of rock. The removal of this material has disturbed the equilibrium of pressure and tension established through geological ages. The tendency at once will be a movement, however imperceptible, to restore this equilibrium of pressure and tension. Slight and inconsiderable as this may be, it will nevertheless operate upon the mass adjacent to the Tunnel, and will be felt in the vertical jointings, and in the lessening of cohesion in the laminæ of bedding, especially in the parts with low dips.

I conceive that the pressure of the mountain mass above the Tunnel must be considered as one of the agencies at work, affecting the safety of the roof; and that this influence will be most apparent where the strata are much cut by vertical joints, and where the beds lie at a dip below 30°. The operations of this canse will not be at once apparent, but will continue for a period of years.

Besides this action, which may be considered that of gravitation, the agencies in operation are water, air and frost.

There is in all the rock throughout the Tunnel a tendency to decay, or decomposition, by the simple action of moisture and air, and this is hastened by the effects of frost during a part of the year. This tendency to decay is not uniform throughout the Tunnel, nor even in all parts of a rock designated by the same term. There are intercalated softer laminæ, or beds, which in the original deposition were of different constitution and composition. These may be more or less pervious to water than the adjacent or prevailing rock. Where these are more pervious, the water finds its way along them, softening and partially decomposing them. In many cases it may be little more than a mechanical action by which the parts crumble and fall away; in other cases the water, percolating through the roof and carrying in solution a notable proportion of carbonic acid, more effectually attacks certain minerals which constitute portions of the rock, or distinct seams cutting the strata.

In many instances there are seams of feldspar, or feldspar and quartz, with nearly or quite the same inclination as the lines of bedding, which sometimes appear to have been a part of the original deposition, and at other times occur as veins. From the decomposition of the feldspar the mass becomes a soft clay, and as these seams are usually the course of water, in greater or less quantities, the material is gradually carried out, leaving a depression along the line. Not unfrequently, in such situations, the strata on one or both sides of the seam become permeated with water, and loosened to such an extent as to crumble away slowly, and if jointed, to fall in masses of greater or less extent. The effect of this action has often extended to several inches on either side, and sometimes a place of one or two feet in width is seen, always moist, and frequently with oozing or dripping water. Even without such seams of different materials, when water finds its way along the lines of jointing or of fracture, the rock becomes disintegrated and more or less rapidly destroyed.

In the line of these joints, or in the lines of fracture, there has been frequent slipping of the beds, which has polished the adjacent faces of the rock, and usually left some soft or crushed material in the interspaces. The percolation of water will remove these materials, leaving the adjacent parts unsupported, which gradually must crumble and fall. All soft seams, whether along slipping joints of the rock, or as veins of other material, will continue to be influenced by the action of water and air; and all such, beyond the dimensions of one or two inches, require careful investigation and protection.

In some places noted, the entire rock is feldspathic in composition, and the softening goes on over large areas. This rock, however, will decay somewhat slowly, and, in the absence of joints, will not be likely to fall in large masses, or to become suddenly dangerous.

Certain portions, and notably some beds between stations 3,400 and 4,000 of the western division, are so feldspathic in composition as already to have become softened and decomposed to a moderate depth; and this process will continue in the future as in the past. The slipping joints, with the slickenside faces of rock, are frequent in the western division.

The danger from these causes depends upon the amount of water and the rate of decomposition; and also, whether the water is limited by a single seam or joint. Whenever the rock is so much jointed that the water percolates over much area, or the quantity of water is great, there is danger of masses falling from the roof.

When the materials loosened and falling shall have been removed, a similar condition will still exist, until, if left alone, the arch shall have become so pointed above as to leave no chance for loose materials to fall.

The conditions existing which are to be considered in providing for the safety of the Tunnel, are: first, the jointed character of the rock for much of the distance in the western division; and, second, the slipping and sometimes crushing of the beds, either along the plane of the natural joints, or along the line of fracture of the strata; also, the veins and seams traversing the rock and becoming softened by the action of water, and the gradual disintegration of some of the beds in place, and their slow decomposition and removal.

These are not all to be understood as imminent of danger; but the roof with much jointed structure, and if also there have been slips, is to be regarded with distrust, and considered as dangerous or doubtful, requiring protection. When this condition is coupled with the dripping of water, and especially if in situations exposed to freezing, the roof must inevitably soon fall.

I hold that even the strongest portions of the roof, if exposed to the alternations of extreme heat and cold, with the freezing of the dripping water, will give way in a few years.

I am not advised as to the intention regarding protection against freezing; but I am informed by the superintendent of the eastern division that the frost penetrated from the portal for more than half a mile; and that the amount of dripping water from the roof was sufficient to form icicles from roof to floor, and thence gradually up, filling the interstices; and, but for frequent removals, would have become a solid mass. Such a condition, if suffered to continue, would of course destroy any roof, whether of stone or brick.

2. "To report as to the amount of brick arching required in order to render the Tunnel safe for the transit of cars."

I have given, in the following pages, a general summary from my notes of observation upon the roof and walls of the Tunnel, as I passed through it. The stations are marked in the margin, and my estimate of the condition placed in the columns of good, doubtful and bad.

I will communicate, as an appendix, an abstract of my notes made at each station, that you may have the data upon which my conclusions have been based.

From the western portal to the distance of 2,200 feet, the Tunnel is already arched; between this and 2,447 (West shaft), all is weak ground. I believe preparations are already made for arching; and I need not include this portion.

WESTERN DIVISION.

	Strong ground, may stand without arching.	Doubtful ground, may stand after careful trimming; needs watching.	Bad or weak ground, needs arching.
	Feet.	Feet.	Feet.
From 2,447 to 3,550,*	–	215	888
3,550 to 4,000, ...	430	–	20*
4,000 to 4,100 (needs arching on one side), ...	–	–	50
4,100 to 4,325 (arch begins at 4,192),	–	–	225
4,325 to 4,510, ...	–	185	–
4,510 to 4,620, ...	–	–	110
4,620 to 6,400, ...	1,780	–	–
6,400 to 6,650, ...	–	–	250
6,650 to 6,700, ...	–	50	–
6,700 to 7,000, ...	300	–	–
7,000 to 7,200, ...	–	–	200
7,200 to 7,400, ...	–	200	–
7,400 to 7,700 (except a vein of feldspar and decomposed rock at 7,550), ...	300	–	–
7,700 to 7,800, ...	–	–	100
7,800 to 8,500 (some parts of this may prove sound), . . .	–	700	–
8,500 to 8,700 (arching begins at 8,550), ...	–	–	200
8,700 to 8,800, ...	–	100	–
8,800 to 8,950, ...	150	–	–
8,950 to 9,300 (weak and uncertain),	–	–	350
9,300 to 9,400, ...	–	100 !	–
9,400 to 9,600, ...	–	–	200
9,600 to 10,150 (requires trimming and careful examination), . .	550 ?		–
10,150 to 11,300, ...	–	–	1,150
11,300 to 11,400, ...	–	100	–
11,400 to 12,000, ...	–	–	600
12,000 to 12,194 [good ?],† . . .	194	–	–
	3,704	1,650	4,393 1,650 3,704 2,447
			12,194

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* This doubtful ground is between 2,447 and 2,750—75 feet; between 2,750 and 2,800—50 feet; 2,800 and 2,915—50 feet; and 2,915 and 3,050—40 feet.

† This roof, however good, will require to be arched near the shaft.

EASTERN DIVISION.

	Strong ground, may stand without arching.	Doubtful ground, may stand after careful trimming; needs watching.	Bad or weak ground, needs arching.
From Portal to station 600, good, with the exception of an open wet joint at 150, which requires special attention, and another of less consequence at 590,	600	–	–
600 to 925 (good if kept from freezing),*	325	–	–
925 to 975 (wet joints),	–	50	–
975 to 1,000,	25	–	–
1,000 to 1,010,	–	–	10
1,010 to 1,030,	20	–	–
1,030 (a wet joint in roof).			
1,030 to 1,275,	245	–	–
1,275 (a quartz vein in roof).			
1,275 to 2,130,	855	–	–
2,130 (a quartz seam, slowly decomposing).			
2,130 to 2,300,	170	–	–
2,300 (a moist soft joint or slip).			
2,300 to 2,615,†	315	–	–
2,615 (a feldspar seam).			
2,615 to 3,925,	1,310	–	–
3,925 (a quartz seam).			
3,925 to 3,980,	55	–	–
3,980 (a quartz seam).			
3,980 to 4,500,	520	–	–
4,500 (a quartz seam).			
4,500 to 4,515,	15	–	
4,515 to 4,525,	–	–	10
4,525 to 4,590,	65	–	–
4,590 to 4,600 (a narrow wet seam),	–	10	–
4,600 to 4,840,	240	–	–
4,840 to 4,860,	–	–	20
4,860 to 5,040,	180	–	–
5,040 to 5,060 (a soft feldspar vein and vein of quartz farther on),	–	20	–
5,060 to 5,720,	660	–	–
5,720 (a crystalline seam).			
5,720 to 5,819,	99	–	–
5,819 to 5,858 (perhaps a greater extent of weak ground, arch begun),	–	–	39
5,858 to 6,000 (rock more slaty),	142	–	–
6,000 to 6,600,	600	–	–

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* A wet joint at 590; a slip in roof at 600, and at 725 a seam of crystalline matter with softened rock on each side, will decompose slowly; not dangerous.

† 2,525 to 2,550 may be examined for quartz seams and the slow influence of decomposition. Other quartz seams before coming to 2,300.

EASTERN DIVISION—CONTINUED.

	Strong ground, may stand without arching.	Doubtful ground, may stand after careful trimming; needs watching.	Bad or weak ground, needs arching.
From 6,600 to 6,640 (an oblique seam with water and decomposing rock), .	–	40	–
6,640 to 6,925, ...	285	–	–
6,925 (a joint on south side).			
6,925 to 7,000, ...	75	–	–
7,000 (a weak seam, dripping water).			
7,000 to 7,310, ...	310	–	–
7,310 to 7,350, ...	–	–	40
7,350 to 7,460, ...	110	–	–
7,460 (seam on south side).			
7,460 to 7,600, ...	140	–	–
7,600 (a seam in roof).			
7,600 to 7,680, ...	80	–	–
7,680 (a joint cutting shale, with much water).			
7,680 to 7,690, ...	–	–	10
7,690 to 7,710, ...	20	–	–
7,710 to 7,720 (a quartz seam extending perhaps ten feet), . . .	–	–	10
7,720 to 8,075, ...	355	–	–
8,075 (a cross-joint with water).			
8,075 to 8,125 (notably at 8,110), .	–	–	50
8,125 to 8,425, ...	300	–	–
8,425 to 8,440, ...	–	–	15
8,440 to 9,000, ...	560	–	–
9,000 to 9,215, ...	–	215?	or 215
9,215 to 9,575, ...	360	–	–
9,575 to 9,725 (much rock fallen between 9,625 and 9,650), . . .	–	–	150
9,725 to 9,800, ...	–	75	–
9,800 to 10,800 (enlarged for arching in part), ...	–	–	1,000
10,800 to 10,900, ...	–	100	–
10,900 to 12,837, ...	–	–	1,937
	9,036	295	3,506 295 9,036
			12,837

The total amount of ground in the western division, which requires arching before it be made safe for the transit of cars, as shown in the schedule, is 4,393 feet:

Of doubtful ground, ...	1,650
Of ground regarded as safe and trustworthy,	3,704

In trimming the roof, it is not improbable that many places, now regarded as doubtful, will be found quite unfit to be left without arching; while some that appear strong at the present time may develop the existence of joints, which will render it doubtful or unsafe to leave without support.

In making an estimate for the amount of arching required in this division, dependent on a more critical examination of the parts, I would not be willing to state it at less than the sum of the bad and the doubtful ground, which amounts to 6,043 feet. The remaining ground may be considered safe for some time to come; but I regard it as almost certain that nearly the whole extent of the western division will ultimately require to be arched with brick.

In the eastern division, the extent of ground regarded as bad is 3,506 feet, to which may be added 295 feet of doubtful ground, making, altogether, 3,801 feet. It is possible that some of the jointed strata, which are now considered as doubtful or bad ground, for a comparatively small distance, may prove to have a greater extension than I have supposed, and you may have to add somewhat to the estimate which I now make from the knowledge acquired during the few days of my investigation, coupled with that derived from the experience of the superintendents of the work during its progress.

There seems no reason to doubt the stability of the strata forming the roof of the greater part of the eastern division of the Tunnel, depending, as I have said, upon their steep and regular dip. But even here the slow processes of decomposition and disintegration will go on, aided by the action of water and frost, when the time will come when the necessity of arching this portion, also, will have to be considered.

3. " To give any other information that you may be able to give, as a geologist, as to the best means of making said Tunnel *perfectly* safe for the passage of passenger trains."

After you shall have decided to arch the dangerous and weaker portions of the roof of the Tunnel, it may not, perhaps, be out of place for me to suggest that provision be made for carrying off the water at the sides of the arch, that it may enter the Tunnel below, instead of being allowed to filter through the arch, as it now does in some parts of that already erected on the western division. The constant percolation of water, and especially when charged with carbonic acid, will gradually dissolve the cement and destroy the cohesion of the parts. Add to this the possibility of freezing, and you have a serious agent of destruction in constant operation.

Should it be decided that there are some portions of the doubtful work which may be considered strong enough to do without arching, for the present, at least, still all such places, except in the firmer ground towards the eastern end, should be carefully watched, and a weekly examination be made by competent and judicious persons, who should pass through the Tunnel on a platform carriage, made high enough to admit of proper inspection and sounding of the roof in all those parts. By such a course accidents would be avoided, and any change in the condition of the rock would be detected in time to prevent it from falling in masses.

Another consideration has occurred to me, which may, perhaps, more properly belong to the province of the engineer than to that of the geologist: it is, that in arching with brick to protect the roof, the arch need not come to the ground on either side; but, by cutting back at the spring of the Tunnel arch, the brickwork may be started upon the stone wall, when the latter is sound enough to sustain it, as would generally be the case. By this process much labor would be saved in the cutting away of the rock in the lateral walls, and much labor and materials saved in the construction of the brickwork. In such a plan, narrow channels should be cut in the stone below the brick, for the passage of all water from the roof to the floor of the Tunnel.

Wherever any portions of the roof which are now wet or dripping water shall be deemed sound enough to stand without arching, especial care and watchfulness should be bestowed upon them; and both from these and all other places the water coming from the roof should be conducted as rapidly as possible, and over as narrow a space or surface of the rock as possible, to the floor of the Tunnel. Above all things, the freezing of the moist or saturated surfaces should be guarded against, as inevitably destructive to the firmest rock of the Tunnel. The action of frost is already perceptible in the exposed softer slates for some distance from the eastern portal.

Should this continue to be exposed to the effects of frost, as heretofore, there will soon be necessity for trimming the roof, at least once a year, to remove such portions as shall have become too much decomposed to cohere, or such as may have been separated at any fracture or fissure.

There will be little danger of any large masses suddenly falling in this division, at any point where the dip is at 40° and upwards; and such dip the beds have from about station 8,000 to the eastern portal. The falling of materials will be from gradual decomposition and crumbling of the rocky mass, or from the same action more rapidly affecting seams of softer material, or those of alternating harder and softer laminæ, which often occur in the same seam or vein; but they are of such a character that I do not apprehend danger from them until the process of decay shall invade the adjacent rock so far as to leave wide openings and unsupported layers on either side.

All portions of the roof which may be cut by vertical or oblique joints, whether included in that recommended for immediate arching or otherwise, will need careful watching and frequent trimming, and, finally, arching with brick. This is more emphatically true of all those parts which are now dripping with water, as I have already stated.

In closing my communication, I can only express my regret that more time could not have been given to the examination of the work, in order that fewer points might have been left in doubt; but with the data and suggestions here furnished, together with the abstract of my notes, and the report of my colleague in geology, you will find all the information which may be required by your able corps of engineers.

I am, very respectfully,
Your obedient servant,
JAMES HALL.

NOTES BY JAMES HALL.

HOOSAC TUNNEL.—WEST OF CENTRAL SHAFT.

STATION 2500. On south side of centre, clay-seam; indicates slipping of surfaces. This point needs support and protection. Also, at 8 or 9 feet,—another seam dipping to south. Between 2500 and 2550, a cross-joint or dike, throwing the rock a little. Whole distance between 2500 and 2600, many joints along roof parallel to direction of Tunnel. Ground better on north side, but bad on south; may be said to be doubtful ground.

2550. After passing 2550, joint in roof containing loose pieces. Bad place in centre of roof, cut by numerous joints, leaving triangular pieces.

2620. Very bad slip-joint in the roof, with some very bad pieces.

2700, from 2620, a slip-joint, not very bad, along south side.

2715. Bad joint, especially on south side; joint with clay. A piece of the roof requires critical attention.

2750 to 2900. Better ground to near 2900. 2850, all wet ground with wet joints, and may be considered doubtful and requiring very careful attention. Just before coming to 2900, ground becomes worse, with some wet joints.

2900. Loose seams and water; very bad ground; slips; close joints.

2915. Ground pretty good till reach 3000.

3000. A seam begins running east, parallel with Tunnel, making ground doubtful. Close joint, parallel to and on south side of Tunnel, requires consideration.

3100. A slip in roof. Near 3100, in centre of roof, several slip-joints, and several pieces fallen out.

3125. Bad slip-joint, making ground very dangerous.

STATION 3200, from 3100. All bad ground. Many slip-joints in roof, which render rocks liable to fall.

3200 to 3300. Similar to that from 3100 to 3200. A glazed slip on south side and overhead in middle; north sides, in some places, better and safe.

3375. A slip or joint of one foot or more of mud, slate and quartz—loose; across Tunnel, showing slickensides.

3300 to 3400. Rock full of slips. Rock often cracked; surfaces smooth from sliding.

3450. Same bad ground continues from 3400. Roof full of slipping joints, and dangerous.

3550. Same description as from 3400.

3550 to 3600. Better ground.

3600. Transverse joint and slip; slightly wet, but not apparently dangerous.

3600 to 4000. By careful trimming, roof may be made safe. Good ground to 4000. Rock better; almost entirely free from glazed slips, and rarely any slickensides.

3975 to 4050. On north side, seam in roof. In some places is open, and needs support from north side. The south and principal part of roof is good.

4050 to 4192. Roof and sides good to this point.

4300 to 4325. Roof very bad.

4510 to 4600. Change in ground. Many seams in roof-joints, with crystalline filling and striated surfaces; some water.

4600 to 6400. Quite free from joints and slickensikes. Rock torn apart at the blast-holes,—not separated at joints,—leaving impression of blast-holes; very dry.

6400 to 6500. Seam in rock running to south side, at 6500, leaving roof supported, owing to dip north. Granite rock.

6530. Arch of 10 or 20 feet will furnish protection. Granite vein cuts Tunnel; arching westward to about 6575 in roof. About 2 feet thick of decomposing mica and hornblende, making loose, shaly mass; wet.

STATION 6600. Joint and dropping water near centre of roof. Some pieces may fall.

6650. Joint on south side leaking much water. From 6600, seams crossing roof obliquely, dripping water, and needs careful examination to see that there are no loose joints.

6700. Some loose joints—not very bad; require attention.

6700 to 6900. Roof and sides good and strong, with few joints and no slips.

7000. Just before reaching 7000, the roof becomes jointed with crossing joints, leaving some loose masses.

7018 and onward to 7200. Many loose joints, containing soft, crumbly material; somewhat wet. Ground on north side is very bad; loose joints with thin layers of matter. South side better. All roof needs attention. Ground dangerons on north side and north half of roof.

7200 to 7400. Seems firm and secure; needs trimming, but not arching.

7550. Loose vein of feldspar, decomposing. Arching over to the east, perhaps safe, but to be looked after.

7700. Begins a vein of feldspar, decomposing; cuts across sides and roof, rendering ground unsafe, and runs to 7775.

7900 to 8000. Open joints dripping water; otherwise not appearing bad.

8000. Much water on north side. Feldspar seam; appears solid, but should be carefully looked after in trimming.

8050. Seam of soft feldspathic granite, decomposing slowly by action of water.

8100. Same as 8050; all seams wet.

8400, just past 8400. Soft feldspathic seam on south side, running obliquely west, but very thin and close. In roof on south side, soft and loose, but dry.

8500 to 8550. Appears as if arch ought to continue westward to 8500, along open seam. Seam quite open at 8522.

8600 to 8700 eastward. Ground decidedly bad; feldspathic seams and wet; indicate decomposition.

STATION 8700. A decided change for the better, and joints disappear. After 8750, some loose pieces in roof, which need to be trimmed off; also at the same point (8750) a dripping of water showing that care is required.

8750 and eastward, Same condition as 8600 to 8700. To 8800 much dripping of water. Roof should be carefully looked after; substance of roof of good character.

8800 to 8950. Roof good.

8950. Strong seam on north side, bearing much water; should be looked after. Seam at 8950 crosses Tunnel obliquely, reaching south wall at about 9015; ground, 8950 to 9015, not reliable, having other causes of weakness.

9035. Seam of decomposing feldspar crosses roof diagonally, and makes bad roof.

9115 eastward. Little better for 50 feet, thence same bad feldspar seam and water to 9200.

9275 to 9300. Ground a little better.

9380. Much water coming in on south side of Tunnel; joint nearly parallel to Tunnel.

9400. A little beyond 9400 another joint, bearing much water; roof and sides bearing much water all the way to 9600. Must be considered doubtful; needs arching.

9600 to 10150. Roof seems good; no danger.

10300. Ground very bad; coarse crystalline granite, decomposing into mud.

10350 to 10700. Same condition as 10300.

10700 to 11050. Same as 10350 to 10700; some parts very bad, and in constant danger of falling. Many seams and much water.

11050 to 11300. Some broken and jointed roof; small joints, cutting ground into small pieces, continue to about 11300, where the roof is a little better in places, but not considered safe.

11300 to 11400. Roof mostly sound and dry; probably can be made safe by trimming.

STATION 11400. A little broken, with leaking ground.

11450. Roof becomes dry, but still jointed.

11500 to 11600. Better roof.

11750. Very bad place in roof; needs careful trimming. Loose joints for considerable distance, and continued to 11850.

11850. Rock becomes more slaty, and roof very dangerous.

11900. Joint across roof, with much water on north side.

11900 to 12000. Same conditions; continues growing worse than before.

12000. Here begins a little better roof, continuing to *Central shaft.* Few joints; all dry; many half drill-holes remaining in roof.

HOOSAC TUNNEL.—EAST OF CENTRAL SHAFT.

STATION 600. Small slip in roof, leaving some loose rock, which may be removed, leaving roof safe.

1000 to 1010. A wet slip, running obliquely to Tunnel, spreads in roof, involving about 2 feet of thickness,—not *presently bad;* may at some future time require protection.

3980. Soft seam, wet and decomposing; not dangerous.

4860. Soft vein, rising nearly in plane with bedding of rock, cutting strata in roof. Much loose matter has fallen from roof; needs some attention.

5040. Soft joint or vein of feldspathic matter arching the whole tunnel,—1 foot wide; but affects rock for about 4 feet in roof; not presently dangerous, but will crumble slowly. Roof good to 5040.

5700. Rock becomes more slaty.

5720. Seam of crystalline matter arching over Tunnel. Rock safe on each side; will decompose slowly.

7600. Short joint on south side.

7680. Joint across Tunnel, with much water.

Station 7720. Quartz vein crossing roof; decomposing slowly. Roof good to 7720.

8100. Vein crosses roof, dividing into several, on north wall; rock between crushed and infiltrated with quartz and feldspar. About 25 feet bad.

8435, and in roof at 8440, sloping backwards; soft vein, interlaminated with harder layers, needs attention.

8500. Short joint on north side; may require looking after, but will not extend.

8550. Joints dripping some water; crossing Tunnel; can do no harm.

8620. No change. Sound, dry rock; very strong.

9000. Joint beginning on north side, running obliquely outwards, so that arch of roof rests upon it; close and strong; no danger of sudden falls.

9100. Joint begins as a double line, and runs parallel to 9135.

9130. Quartz vein from 9200, dividing at this point. Not unsafe east of 9130.

9200 to 9215. Soft seam, 15 inches wide, crossing Tunnel at angle of 75°. Roof good each side.

9300 to 9400. No change from 9500.

9500 from 9575. Roof very good and strong; no joints of importance, and continues to 9400. Dip high.

9575 from 9725. The roof cut by numerous joints in different directions. At one point some tons of rock have fallen from roof (9625–9650); all very dangerous.

9725 from 9800. Roof better; not so good just at 9725.

9800. Soft, wet seam crossing from south side over roof. Other joints and loose pieces in roof; wet in places. Dip gradually rising; is now about 40°.

9900. Slip or joint along north side. Same condition of roof as before noted. Many wet joints, with water and slips. Longitudinal joints, which have been following along the roof (10600), crossing to south side, causing much bad roof.

STATION 9975 to 10100. Enlarged for brich arch.

10000. Roof very dangerous; roof much cut by joints in various directions. Joints wet, and roof falling.

10100 from 10200. Condition worse, if possible. Many joints; principal one on north side; shorter ones on south side. Some masses lately fallen from centre of roof. Now contains many loose pieces. Mr. Blue states it was entirely trimmed of loose ground one and a half years ago.

10200. Wet joint running nearly to 10300, on north side of Tunnel, dripping much water. Some cross-joints very dangerous.

10300 from 10400. No change worth noting.

10400 from 10500. Same kind of roof as before—with joints worse, if anything. On south side very bad, and near the station worse on north side.

10500 from 10600. Same joint on south side of Tunnel, with cross-joints in roof; many loose pieces in roof; little water. Blue says it was some time ago trimmed and made sound; is now quite loose.

10600 from 10700. Very bad roof, joints cutting in several directions, leaving very bad roof. Some joints wet. Water dripping all along. Pieces have fallen from roof.

10700 from 10800. Dangerous slips or joints, and pieces of roof liable to fall at any time.

10800 from 10900. Roof better; drill-holes showing; dry, with no important slips.

10900 to 10915. Slip across roof; and another on south side.

11000. Same kind of roof and walls, with joints and loose pieces in roof. A soft clay seam crossing roof at this point, from which pieces have fallen.

11100. Roof flaky and shaly, with cross-joints, and in danger of falling.

11200. Roof, since passing 11400, very shelly. Sounding roof shows many pieces loose and ready to fall. Loose pieces lately removed.

11300. Same kind of roof as 11325; roof flaky and shaly.

STATION 11325 to 11375. Enlarged for arching; wet slipping joint.

11400. Roof with few joints. Just east of 11500, joint running entirely across Tunnel and up each wall.

11500 to 11600. Generally same conditions as last 100 feet; few joints, though several at 11500. Roof very flat. Rock generally good.

11600. Generally a little better roof from 11700; no slips of consequence; strata generally too flat.

11700. Diagonal joint crossing to north-west over roof of Tunnel.

11735 to 11843. Already enlarged for brickwork at 11800. Soft decomposing seam, one foot thick at base, increasing to five feet in roof.

11900. Joint running up side Tunnel and across roof. Between 12000, and 11900 one cross-joint, dripping much water from roof. Going east, wet joints again.

12000. A little better, but some joints, and roof flat; quite dry.

12150. Cross-joint from base across roof; wet in roof; no drill-holes showing in roof. Roof weak from joints to 12000, where it becomes free from joints.

12200 to 12300. Same broken condition as 12300 to 12400, with little water so far as observed. Almost no marks of drill-holes left in roof.

12300 to 12400. Continuous joint along south side; north side with regular joints and wet slips, leaving roof without support.

12400. Roof same kind as at 12500, with joints, leaving portions ready to fall, and some water at intervals. Diagonal seam or joint across roof.

12500. Slip; rock cracked, joints on south side; some water.

12550. Wet slip on north side, and a joint along the centre.

12600. Longitudinal and cross-joints in roof; a little water on north side.

12837. Wet slips at side, running up nearly vertical, making bad ground.

REPORT OF T. STERRY HUNT.

To Dr. P. A. Chadbourne, *for the Corporators of the Hoosac Tunnel.*

Sir :—In obedience to the instructions received from you, dated September 14, 1874, naming me one of the experts to examine and report upon the condition of the Hoosac Tunnel, in accordance with section 5 of Senate Document No. 361, 1874, I have the honor to inform you that I made an examination of the Tunnel on September 22–26, and collected such rock-specimens as were necessary for my farther study, which were duly fowarded to me at Boston. After a careful study of these, and collation of the notes made by me during the examination, I beg to make the following Report.

Following the order indicated in my instructions, I shall begin by noticing the kind of rock and its structure, considered in relation to the safety of the Tunnel. The rock at the two extremities, and for about three-fourths of the entire distance, is a mica-schist or a micaceous gneiss, the two rocks differing from each other in the proportions of their mineralogical constituents, and the mica-schist (or mica-slate, as it is also termed) passing into gneiss by a larger admixture of quartz and feldspar. Many varieties of these rocks may be seen in the Tunnel, from a very soft and flaky mica-schist to a gneiss of great hardness and strength, and these varieties alternate and graduate into each other, as is always the case in the great mica-slate formation of the Appalachians, of which formation these rocks are a part. To the west of the Tunnel there is a cutting through a band of white limestone, but a short distance before reaching the west portal the mica-slate and gneiss formation, in a decomposed state, is met with. Farther in, after passing the long brick arch, at the foot of the west shaft, a distance of 2,447 feet, the same rocks are still met with, though undecomposed. Thence, to 3,750 feet (counting from the west portal), the same formation continues, sometimes very soft and micaceous, at other times hard and feldspathic. At this point the rock is a dark, very micaceous gneiss, with garnets, and the strata appear nearly vertical. This is followed by a soft mica-schist, but at about 3,900 feet these rocks are replaced by a white, hard, feldspathic rock, sometimes quartzose, occasionally with a little mica in layers. Sometimes it is nearly compact, and at others is coarsely granular, and may be designated a gneiss. The inclination of the strata is high, with many small contortions and a local westerly dip at 4,100, the general dip of the strata throughout the Tunnel being to the eastward. East of the second brick arch (4,192–4,253 feet) a hard feldspathic rock continues, which in some parts is fine grained, almost compact, and white in color, with greenish spots, which are apparently due to the presence of a small amount of diffused light green hornblende, minute prisms of which are in some places to be recognized. This rock, which holds in some abundance seams of calcareous spar, continues up to 6,150 feet, with but little apparent change. Here it becomes coarser grained, and is seen to contain othoclase-feldspar and quartz, becoming a light colored, somewhat granitoid gneiss. This is more distinctly defined farther on, and is very well characterized at 6,700 feet. It thence continues, with small variations, to about 10,700, where it is succeeded by a grayish-black micaceous gneiss, very like that seen between the west shaft and 3,900. A similar gneiss appears up to 11,050, where the gneiss, still dark colored, becomes very coarse grained, and shows a dip of about thirty-five degrees to the eastward. Beyond this re-appear mica-schists and micaceous gneisses, apparently like those of the western end, which extend all the way to the central shaft (12,764 feet), and beyond it to the east portal, and still farther. These rocks present considerable alterations in quality, as before, and are in some parts hard and gneissic, and in others soft and micaceous. The former character is well seen in the strata from 6,000 to 9,500, and again in the vicinity of 12,000 feet, counting in this eastern half of the Tunnel from the east portal. Near the central shaft and to the west of it, the rock, as already noticed, has a moderate easterly dip, and this is observed for some distance to the eastward, but at 9,570 feet in the eastern division it increases to forty-five or fifty degrees, and augments until, farther on, the dip becomes nearly vertical. The Tunnel may be described as passing for 25,000 feet through a hill of mica-schist and micaceous gneiss, including in its western half over 6,000 feet of hard feldspathic and quartzose rock, in part a granitold gneiss.

The decay of the rock seen at the west portal, already noticed, consists in a chemical change, which has converted the feldspar of the gneiss into a clay. The strata still retain their original positions, but the whole mass is so soft as to be readily moved by the spade, This state of decay was, I am informed, found to be complete for a distance of 600 feet from the west portal, where the floor of the Tunnel is 200 feet below the surface of the hill, and was partial at 1,000 feet, where it is 280 feet below. The question has been raised, whether this condition of things is one likely to extend, and to affect the strength and safety of the Tunnel still farther in. I have paid especial attention to the same phenomena of decay, where they are seen to a great extent in the similar rocks of the Blue Ridge in Virginia and North Carolina, and have satisfied myself that the process is one belonging to an age long past, and that at one time the whole of the rocks of Hoosac Mountain were, to a considerable depth, in the same condition. The agencies which have removed the decayed rock from the other parts of the mountain have, however, spared this protected portion at its western base, where it still remains, an evidence of a process which has not since affected the exposed and still undecayed portions of the similar rocks which form the surface of the whole mountain.

The strength and safety of the roof of the Tunnel have much less to do with the mineralogical characters of the rock, or with its stratification, than might be supposed; and, on the contrary, have very much to do with joints and fissures in the rock pertaining to the superinduced structure which belongs to the architecture of the mountain. The strata have, since their formation, been subjected to movements and strains of various kinds, which have not only contorted them, but apparently produced greater or less movements of dislocation, crushing them in parts. As a result of this, joints have been produced which traverse large portions of the rock in directions which have no constant relation to the stratification, and are a source of weakness. In the more fissile or slaty portions of the rock there is a proneness to split or cleave in the direction of the stratification, but this is seldom of much consequence, while, on the other hand, the hard and compact varieties of rock, which have no tendency to cleave in this manner, are often so traversed by joints as to make the roof unsafe. In many cases the prominent joints are nearly perpendicular, and run east and west, coinciding for considerable distances with the line of the Tunnel. It not unfrequently occurs that there are several of these in its breadth, and that the separation of the rock along them forms one or both walls of the Tunnel. These joints, being perpendicular and more or less open, then extend up along the walls, leaving the roof without lateral support. It thus happens that when there are several of these parallel joints in the roof of the Tunnel, and when, moreover, as is often the case, the roof is intersected by other vertical joints running in directions transverse or more or less oblique to these, portions of the rock are left with but little support; and when still other joints or planes of division occur, which are either horizontal or make but a small angle with the horizon, the condition is still more unstable, and angular blocks of greater or less size hang in the roof with insufficient means of support. When, however, these principal vertical joints are oblique to the axis of the Tunnel, the roof is better sustained. This condition of things, which I have endeavored to describe, is more marked in the harder and granite-like rocks than in the softer and more yielding slaty portions in which the fissures are fewer in number, less open, and less important. These softer strata are, however, apt to split in the plane of the beds, and in the parts where these are at a small angle, occasionally make an unsound roof, but where they are at a high angle, form a very firm and solid one. It will thus be seen, that so far as the kind of rock is concerned, the softer varieties afford a better roof than those which are harder and more firm.

A point of much importance in connection with the stability of the roof is connected with the percolation of water, which in some places filters slowly through the rock, keeping portions of it wet, while in other places it drips abundantly. Here, again, there is no apparent connection between the flow of water and the kind of rock, some parts of the granitoid rock being very wet, and others dry. Considerable water comes through the mica-schists in the western half of the Tunnel, but the eastern half is, with some few exceptions, dry. The great flow of water during the exacavation was a little west of the central shaft. The importance to be attached to the water is twofold: in the first place, it shows the existence of more or less open joints, which are, in themselves, points of weakness, and by the wearing action of the water may become gradually enlarged; in the second place, in those parts of the Tunnel which will be exposed to the action of frost, the freezing of the water in the cracks of the rock will tend to open the joints and thus loosen fragments. The danger from this cause would perhaps be greater where the flow of water is very small, for where it is considerable the temperature of the water, being much above the freezing point, will probably prevent the formation of ice in the fissures. In such localities as permit of its formation, the accumulation of ice either on the floor or on the roof or walls, and its subsequent fall therefrom, are possible sources of danger to be guarded against, and to be carefully studied. I venture to recommend that during the next winter, when the Tunnel will be open (the door at the western end having been removed), observations shall be made within it, at various points, by means of registering thermometers, to determine the minimum temperature and to show how far the frost will penetrate during the continuance of severe cold, with westerly winds. In the eastern half of the Tunnel, the comparative dryness will make such observations less important than in the western, though they should not be neglected. The effect of frost upon the brick arch of 2,200 feet at the western extremity, along which there is a considerable percolation of water, should be carefully studied.

As regards the second point in your instructions; namely, the amount of brick arching required to make the Tunnel safe for the passage of railroad trains, it is a question the consideration of which belongs rather to the civil engineers who are to report upon the work than to myself. I will, however, give some notes of the condition of the roof and of the judgments which I formed on the spot. I examined it from end to end, very carefully, with the aid of lights carried along the roof, and a pole, armed with iron, for sounding it; much of the ground having been gone over twice in this manner.

Begining at the west portal and counting eastward as far as the central shaft, the first 2,447 feet are already arched or to be arched with brick. From this point to 3,700 feet, the rock is a soft mica-schist, having great parallel fissures running with the axis of the Tunnel and often coinciding with its sides, together with transverse joints, sometimes very flat. Between 2,700 and 2,800 feet are from fifty to seventy-five feet of good roof, but beyond this, to 3,500, the roof, as before, is cut up by longitudinal and transverse seams, and with the exception already named, the whole of this distance of more than 1,000 feet appears to me to be unsafe. From 3,500 to a brick arch, which extends from 4,192 to 4,253, the roof seems to be sound and firm, but beyond the arch to 4,350, there are frequent flat seams, making the roof, in my opinion, uncertain for the distance of 100 feet. Beyond this, up to 6,390, the roof appears firm and good, with one exception to be noted, at 4,050, where an open vertical joint, extending along the north wall, begins, and is continued about fifty feet, the rock appearing loose and unsound for two or three feet to the south of it, although the remaining breadth seemed firm and solid. From 6,390 to 6,410, a distance of twenty feet, the rock, here a granitoid gneiss, is much fissured, and lets fall abundance of water. A similar flow of water through fissures occurs at intervals all the way to 6,700, and the whole roof for this distance of more than 300 feet appears to me unsound. Thence for 300 feet farther, or to 7,000, it is dry and solid, without open joints; but between 7,000 and 7,200, a great, open, vertical joint runs along the north wall, which sounds hollow; the roof here requires attention. Thence to 7,400, it is rough but dry. It shows some large fissures in the last fifty feet, and will require careful watching, as will also the next 300 feet, which are somewhat cut up by seams. This brings us to 7,700 feet and thence to the brick arch

(8,550–8,600) the roof is very good; but beyond the arch for 100 feet, or to 8,700, it is loose and unsound, and will require arching. Thence to 9,050 it is good and sound, but beyond, for fifty feet, or to 9,100, it is cut by great seams, is more or less wet, and appears unsafe. At 9,200, for a distance of ten feet, the roof is much cut up by seams, but with this exception appears good from 9,100 to 9,400. Thence, a distance of 100 feet, to 9,500, it is leaky, with many joints and fissures, and requires to be carefully examined. From 9,500 to 10,260, the roof is free from joints, dry, and seems solid and in excellent condition. From this point for about seventy-five feet, or to 10,335, is a portion much cracked and fissured, with a clayey matter in the joints, while the granitoid gneiss rock is traversed by seams of soft, dark, micaceous material. This part is now timbered and will be arched with brick. Thence to 10,525 the roof appears sound, but from this point to 11,050, it is much cut by joints, is very wet in places, and seemingly unsafe. For 200 feet beyond, or to 11,250, the roof is sound and firm; but for thirty feet farther, or to 11,280, it is again much cut up by joints, beyond which to 11,400, it is sound and dry. From 11,400 to 11,500 it is also dry, but with nearly vertical transverse seams and others nearly horizontal, making the roof seem unsound. From 11,500 to 11,750, it is again sound and firm, but from this point to 11,950, is intersected by joints, as before, is wet, and appears unsound; beyond, to nearly 12,000, the roof is very wet, and is timbered. From this point to the central shaft, at 12,194, the roof is dry and solid.

I now come to the eastern division of the Tunnel, in which the stations are numbered from the east portal westward; but, in my notes, I shall continue in the previous course, from west to east, the central shaft being at 12,837 feet from the east end. From the shaft to 12,764 feet, the roof is in good condition; but thence, for 64 feet, there are parallel joints coinciding with the sides of the Tunnel, and leaving the roof apparently without support. From 12,700 to 12,660, the roof is somewhat better; but thence, for 410 feet, to 12,250 the strata, which have a gentle dip to the east, are soft mica-schists, cut up more or less by joints in two directions, and often giving out a hollow sound when struck. The greater part of this 410 feet will, I think, require arching. From 12,250, the roof is good as far as 11,825; thence, to 11,735, is a portion of soft mica-schist, very wet, where preparations are now being made for arching. From this last point to 11,385, there is again a good roof, to which succeeds a broken and leaky portion of fifty feet, now being excavated for arching. Beyond this, a joint or seam, nearly parallel to the north wall, extends along it to 11,225, and farther, all the distance to 11,000, are frequent parallel and transverse seams, which make the ground, in my opinion, unsafe for 225 feet. For 900 feet farther, or to 10,100, a somewhat similar condition of things is met with, the roof being intersected with parallel and transverse joints, often somewhat open. Of the former, two or three are frequently seen in a breadth of ten feet, and half-detached blocks in the roof often give it the appearance of great insecurity. The succeeding 150 feet, to 9,950, are now being prepared for arching; and thence to 9,800, there are, as before, many joints, which are often open, while the rock is more or less wet. For 100 feet beyond, or to 9,700 the roof is strong, dry and solid; but beyond, to 9,570, it is again much fissured and insecure. From this point to 9,125, it is good and sound; but thence, to 9,000, the roof is more or less fissured, and requires attention. From 9,000 feet to the east portal, the strata of mica-schist and micaceous gneiss have a high and increasing dip to the eastward, which soon becomes nearly vertical. The roof is sound and dry, and appears safe throughout the whole distance, with the exception of a few short portions, which will require arching. These are at 8,430, where there is a narrow soft seam, dipping with a high angle to the east; a similar seam at 8,125–8,100; two thin seams of soft rock, with much water, at 7,600; and a point begining at 5,858, where a brick arch of thirty-nine feet has already been built. Beyond this are other points, at 5,050, 4,860, 4,525 and 1,010, where short arches will be required; but with these trifling exceptions, the last 9,000 feet of the Tunnel are, in my opinion, firm and safe.

Reviewing, now, the preceding notes, it will be seen that the portions which I have indicated as unsafe in the west division of the Tunnel, are as follows:—

West Division.

A, .	2447 to 3500, .	1,000 ft.	I, .	9200 to 9210, .	10 ft.
B, .	4253 “ 4350, .	100 “	K, .	9400 “ 9500, .	100 “
C, .	4050 “ 4100, .	50 “	L, .	10260 “ 10335, .	75 “
D, .	6390 “ 6700, .	310 “	M, .	10525 “ 11050, .	525 “
E, .	7000 “ 7200, .	200 “	N, .	11250 “ 11280, .	30 “
F, .	7350 “ 7700, .	350 “	O, .	11400 “ 11500, .	100 “
G, .	8600 “ 8700, .	100 “	P, .	11750 “ 11950, .	200 “
H, .	9050 “ 9100, .	50 “	Q, .	11950 “ 12000, .	50 “
Total, ...					3,250 ft.

East Division.

R, .	12764 to 12700, .	64 ft.	W, .	10100 to 9950, .	150 ft.
S, .	12660 “ 12250, .	410 “	X, .	9950 “ 9800, .	150 “
T, .	12825 “ 12735, .	90 “	Y, .	9700 “ 9570, .	130 “
U, .	13385 “ 11225, .	160 “	Z, .	9125 “ 9000, .	125 “
V, .	11225 “ 10100, .	1,125 “			
Total, ...					2,404 ft.

All the ground which I have thus indicated, making an aggregate of 5,654 feet, appears, in the present state, to be unsafe; but it does not follow that the whole thereof will require arching. At many points, more especially in the eastern half, falls of stone from the roof, from a few pounds to several tons in weight, have taken place during the past few months, from ground which had been looked upon as sound; but it is to be kept in mind that these falls do not indicate an increasing danger, as in the case of stones falling from a weakened and crumbling structure, destined to ruin. On the contrary, each fall of rock from the roof of the Tunnel diminishes the future risk in that spot. The roof has been more or less shattered by the explosive agents used in excavating the Tunnel, and it is the loosened fragments which are now falling from time to time. When these shall all have fallen, the roof of the Tunnel, unless where the disintegrating force of water is at work, will have acquired a condition of stability, a process which, in the course of nature, would, however, require a long time. In many portions of the Tunnel, where I have marked the cracked and jointed condition of the roof, this process will be aided by the removal of the seemingly loose portions of rock, and the necessity for arching dispensed with. This may be found to be the case with the parts which I have designated by the letters K, M, N, and with parts of V. Where, as in C and E, the weakness seems to be confined to a crack along the side of the Tunnel, it is worth inquiry whether some mode of support by buttresses cannot be substituted for arching. I, however, hesitate to express an opinion as to the probable amount of arching which may ultimately be required to make the Tunnel safe, because it is, I conceive, a matter upon which the civil engineers who are to follow me, are more competent to decide than myself. In indicating, as I have done above, the doubtful portions of the Tunnel, it may be thought that I have erred on the side of prudence; but I have felt in the task a sense of great responsibility, and, in that spirit, have endeavored to form my conclusions.

In closing, I venture to add to the suggestions as to the examinations of temperature, and the effects of the winter's frost upon the Tunnel, that of frequent and regular inspections by means of lights, sounding-poles, and, where necessary, of ladders, of the entire roof and walls. For this purpose, it will be important to retain the services of men who have become familiar with the Tunnel, and who will be able to make intelligent observations as to the changes, if any, which are taking place in its condition. In this way, under careful supervision, it will be possible to get together a body of information as to the Tunnel, which will be of great service as regards the future management of this important work.

I have the honor to be, sir,
Your most obedient servant,

T. STERRY HUNT.

BOSTON, MASS., October 12, 1874.

REPORT OF JOSIAH BROWN.

Fall River, October 13, 1874.

To Wm. B. Washburn, Esq., and P. A. Chadbourne, Esq.:

Gents:—In compliance with your request, I have examined the Hoosac Tunnel as carefully as circumstances would admit. I am satisfied that it is impossible to tell with certainty every place that is necessary to be arched, without a careful examination after the sides and roof have been trimmed and all loose pieces removed.

I found a large portion of the sides and roof marked to be trimmed to the size required by the contract. This made it unnecessary for me to sound or examine very closely those parts, as the trimming will change very much the appearance.

The notes that I took when in the Tunnel of the seams and joints, I will give you if desired.

The following, in my judgment, are the stations and distances required to be arched, in order to make it safe for the passage of trains:—

Stations and Distances required to be Arched.

WEST DIVISION. *West Portal to Central Shaft.*		EAST DIVISION. *Central Shaft to East Portal.*	
STATIONS.	Distances to be Arched.	STATIONS.	Distances to be Arched.
2,447, West Shaft.		12,837, Central Shaft.	
2,447 to 3,500,	1,053 feet.	12,837 to 12,700,	137 feet.
3,975 to 4,180,	205 "	12,650 to 12,350,	300 "
4,250 to 4,350,	100 "	12,000 to 11,950,	50 "
4,400 to 4,575,	175 "	11,850 to 11,700,	150 "
6,400 to 6,680,	280 "	11,450 to 9,810,	1,640 "
6,975 to 7,200,	225 "	9,725 to 9,550,	175 "
7,300 to 7,400,	100 "	9,250 to 9,050,	200 "
7,700 to 7,800,	100 "	8,535 to 8,425,	110 "
7,980 to 8,000,	20 "	8,115 to 8,000,	115 "
8,460 to 8,500,	40 "	7,660 to 7,640,	20 "
8,525 to 8,556,	31 "	7,475 to 7,425,	50 "
8,594 to 8,700,	106 "	6,400 to 6,380,	20 "
8,780 to 8,980,	200 "	5,819 to 5,809,	10 "
9,030 to 9,300,	270 "	5,720 to 5,710,	10 "
9,350 to 9,400,	50 "	5,060 to 5,040,	20 "
9,420 to 9,650,	230 "	4,875 to 4,850,	25 "
9,750 to 10,000,	250 "	4,600 to 4,590,	10 "
10,250 to 11,000,	750 "	2,625 to 2,610,	10 "
11,000 to 12,000,	1,000 "	1,035 to 975,	60 "
12,000 to Shaft,	194 "		3,112 feet.
	5,379 feet.		

West Division,	5,379 feet to arch.
East Division,	3,112 " "
Total,	8,491 feet to arch.
Equal to	$1\frac{608}{1000}$ miles.

Yours, respectfully,

JOSIAH BROWN.

REPORT OF D. L. HARRIS.

Hon. P. A. Chadbourne, *of the Boston, Hoosac Tunnel and Western Railroad Company.*

Sir:—Having, in compliance with instructions contained in your communication of the 8th of October, made an "examination of the Hoosac Tunnel with a view to ascertaining how much thereof should be arched in order to insure the safe passage of railroad trains through the same," I respectfully present the following Report:

The easterly part of the Tunnel, say about one-third of its entire length, is driven through compact and tenacious mica-slate rock, with strata highly inclined to the west, and standing at nearly right angles to the centre line. Through this portion there are occasional seams of rotton rock or soft material, varying from a few inches to two feet in thickness, running across the line of the Tunnel and cutting the regular strata at varying angles. At these points it will be necessary, "in order to insure the safe passage of railroad trains," that short pieces of arching, amounting in the aggregate to 280 feet, be built. With these exceptions, the side and the roof of the Tunnel present a firm and reliable appearance. So far as the trimming is completed, the contour of the roof is uniformly well defined, neat and suggestive of perfect safety.

At about 9,000 feet (or station 90), from the east portal, a section of 220 feet of arching should be commenced.

Next follows about 330 feet of apparently sound roofing.

Near 9,550 feet from the east portal, there is a marked change in the general appearance of the Tunnel. The rock changes in structure and holds more moisture in combination with its elements. Running water is freely discharged from seams and slips, and the rock-beds are less and less inclined to the horizon, so that before reaching the central shaft they become nearly flat. The "completed" Tunnel loses that regular and symmetrical figure which obtains in the eastern section, and the exposed rock has a shattered and unstable look. Arching is required all the way.

Going west from the central shaft, the rock formation becomes more granitic, water is very abundant in the seams and slips, stratification is less distinct, with natural beds of the rock nearly horizontal, and the general appearance is such as to leave no doubt that the arching should be continuous to a point not far from 10,000 feet (or station 100) westerly of the west portal of the Tunnel. This would give an unbroken line of arching about one mile long and extending nearly equal distances each way from the central shaft.

From station 100 (10,000 feet) to station 25 (2,500 feet), measuring from the west portal, there is an improvement in the rock formation at some points, though it nowhere compares favorably with that of the east end section. Minerals of alkaline of readily disintegrating character are found in the cross-veins, and it is evident that large portions of the rock bounding the Tunnel are more or less affected injuriously by exposure to the combined influence of air and moisture. In some places arching may be avoided for several hundred feet together, but the safe places are the exceptions. The good and the bad are sadly intermixed. In the whole 7,500 feet now under consideration, there may be in all 2,000 feet that, with proper trimming, will be safe.

From station 2500, onwards to the west portal of the Tunnel, arching is completed.

My conclusions may be summed up as follows :—

Arching is required—	Lineal feet.
In the easterly 9,000 feet of Tunnel at nine places, measuring in the aggregate	280
At about 9,100, counting from the east portal, . .	220
Between a point 9,550 feet from the east portal and a point 10,000 feet from the west portal, . .	5,081
Between the last named point and a point 2,500 feet from the west portal, sundry sections, amounting in the aggregate to	5,500
Total, ...	11,081

Respectfully submitted,

D. L. HARRIS.

SPRINGFIELD, MASS., October 16, 1874.

REPORT OF THOMAS DOANE.

To the Corporators of the Boston, Hoosac Tunnel and Western Railroad Company, Hon. W. B. WASHBURN, *President.*

Under your appointment, and in accordance with Senate Document of the year 1874, No. 361, section 5, I beg leave to report concerning my examinations of the Hoosac Tunnel, and my conclusions therefrom, as follows :—

On the 30th September, 1874, that portion lying between the east end and the central shaft, was examined, with the assistance of Superintendent Blue and Engineer Locke.

On the 1st October, the easterly one-half of that portion lying between the central shaft and the west shaft, was examined, in company with Superintendent Roscoe and Engineer Cole.

And on the 2d October, the westerly one-half of that portion lying between the central shaft and the west shaft was examined by the aid of Superintendent Hicks and Engineer Fisher.

The examinations were made on foot, the roof being lighted by three to four lamps carried upon a long pole, and swung from side to side, and sounded, when required, by means of an iron ram upon the end of another pole.

The Messrs. Shanly provided three additional attendants to aid in lighting and sounding the roof, and in carrying oil for the lamps.

No measurements were made by me in the Tunnel, except the fractional ones required between the engineer's stations. These stations are 100 feet apart, marked upon the walls, and are taken to be right, the whole summing up to the entire length of the Tunnel, which is well known and established.

The observations made were located by reference to these stations.

The stationing is numbered from both ends towards the central shaft.

The easterly portal is at station 0.

The central shaft, measuring from the easterly portal, is at station	128.37
The central shaft, measuring from the west, is at station	121.94
The westerly portal is at station, *minus*, .	.50
The total length of the Tunnel, when done, will be the sum of these distances, . .	25,081 feet.
Which is equal to	4.7502 miles.

A graphical delineation of the Tunnel, and of the observations made, with notes upon the different parts, is herewith presented and made a part of this Report. By a reference to this, the relations and proportions of the parts to each other and to the whole, may be more clearly seen and understood than by any possible written description.

The scale of it is 500 feet to an inch, and the profile of the mountain is natural.

The following is a tabular summing up of the examinations and conclusions.

All the figures in the tables represent feet.

East of the Central Shaft.

From Station—	To Station—	Finished and safe.	Roof to be trimmed to semi-circle.	To be trimmed and partly lined with brick.	To be wholly lined with brick.	Now lined with brick.
0,	50,	–	50	–	–	–
50,	975,	925	–	–	–	–
975,	1,017,	–	–	–	42	–
1,017,	1,850,	833	–	–	–	–
1,850,	3,500,	–	1,650	–	–	–
3,500,	4,840,	1,340	–	–	–	–
4,840,	4,870,	–	–	–	30	–
4,870,	5,043,	173	–	–	–	–
5,043,	5,063,	–	–	–	20	–
5,063,	5,720,	657	–	–	–	–
5,720,	5,737,	–	–	–	17	–
5,737,	5,819,	82	–	–	–	–
5,819,	5,858,	–	–	–	–	39
5,858,	6,600,	742	–	–	–	–
6,600,	6,640,	–	–	–	40	–
6,640,	7,650,	1,010	–	–	–	–
7,650,	7,670,	–	–	20	–	–
7,670,	8,100,	430	–	–	–	–
8,100,	8,125,	–	–	–	25	–
8,125,	8,427,	302	–	–	–	–
8,427,	8,442,	–	–	–	15	–
8,442,	8,980,	538	–	–	–	–
8,980,	9,220,	–	–	–	240	–
9,220,	9,575,	355	–	–	–	–
9,575,	9,725,	–	–	–	150	–
9,725,	9,815,	90	–	–	–	–
9,815,	10,850,	–	–	–	1,035	–
10,850,	11,325,	475	–	–	–	–
11,325,	11,375,	–	–	–	50	–
11,375,	11,735,	–	360	–	–	–
11,735,	11,843,	–	–	–	108	–
11,843,	12,200,	–	357	–	–	–
12,200,	12,837,	–	–	–	637	–
Total East End,		7,952	2,417	20	2,409	39

West of the Central Shaft.

FROM STATION—	TO STATION—	Finished and safe.	Roof to be trimmed to semi-circle.	To be trimmed and partly lined with brick.	To be wholly lined with brick.	Now lined with brick.
12,194, . .	11,940, . .	–	–	–	254	–
11,940, . .	11,030, . .	–	910	–	–	–
11,030, . .	10,775, . .	–	–	–	255	–
10,775, . .	10,650, . .	–	125	–	–	–
10,650, . .	10,530, . .	–	–	–	120	–
10,530, . .	10,350, . .	–	180	–	–	–
10,350, . .	10,270, . .	–	–	–	80	–
10,270, . .	10,000, . .	–	270	–	–	–
10,000, . .	9,900, . .	–	–	100	–	–
9,900, . .	8,603, . .	–	–	–	1,297	–
8,603, . .	8,554, . .	–	–	–	–	49
8,554, . .	8,450, . .	–	–	–	104	–
8,450, . .	7,800, . .	–	650	–	–	–
7,800, . .	7,700, . .	–	–	–	100	–
7,700, . .	7,200, . .	–	500	–	–	–
7,200, . .	6,900, . .	–	–	–	300	–
6,900, . .	6,700, . .	–	200	–	–	–
6,700, . .	6,400, . .	–	–	300	–	–
6,400, . .	4,305, . .	–	2,095	–	–	–
4,305, . .	4,251, . .	–	–	–	54	–
4,251, . .	4,192, . .	–	–	–	–	59
4,192, . .	4,000, . .	–	–	192	–	–
4,000, . .	3,550, . .	–	450	–	–	–
3,550. . .	3,120, . .	–	–	–	430	–
3,120, . .	2,700, . .	–	420	–	–	–
2,700, . .	2,530, . .	–	–	–	170	–
2,530, . .	2,457, . .	–	73	–	–	–
2,457, . .	2,360, . .	–	–	–	97	–
2,360, . .	—50, . .	–	–	–	–	2,410
Totals West End, .		–	5,873	592	3,261	2,518
Totals East End, .		7,952	2,417	20	2,409	39
Totals both Ends, .		7,952	8,290	612	5,670	2,557

Total now lined with brick, ...	2,557
to be wholly lined with brick, ...	5,670
to be trimmed to semi-circle and partly lined, .	612
to be trimmed to semi-circle without brick lining,	8,290
finished and safe, ...	7,952
Total length of Tunnel, ...	25,081

The portion pronounced above as finished and safe is in process of being trimmed of its loose or shaken stone by the Messrs. Shanly, in the completion of their contract.

It is presumed that this will be all that is necessary through the 7,952 feet.

No human wisdom can determine exactly what must be done nor how much, to make the Tunnel complete, nor where to draw the precise line between safety and danger.

But if the amount of work comprehended in the above table be done; that is, if 8,290 lineal feet of roof, now too flat, be trimmed to a semi-circle; if 612 lineal feet of Tunnel, now nearly safe, be made quite so by legs of masonry or bits of arching here and there; and if 5,670 lineal feet of Tunnel be wholly lined with brick, then it will be almost certain that it will be safe, and that it will meet all the demands of a travelling people.

Perhaps very considerably less work than is anticipated above will meet these requirements, but *this can only be determined while it is being carried forward.*

As for instance, in trimming the roof, which now seems doubtful, for 8,290 feet, it may be found, before the whole of the rock is removed which is necessary to bring it to a semi-circle, that it has become so firm, and taken such a form, that its safety can no longer be doubted.

Again: in enlarging for the proposed brick masonry through the 5,670 feet, in doing which it is necessary to bring the roof to a semi-circle,—for no one would advise a flattened arch,—it may be found that the removal of the shattered rock, and the change of form of roof thus brought about will together make portions of it safe *without* masonry.

In addition to the above, the corporators desire "the making to them of any suggestions that may occur, as to any agency now in operation, or that is likely to be in operation, tending to render the said Tunnel, or any portion of it, unsafe for the passage of railroad trains."

In accordance with the desire thus expressed, it is deemed proper to offer the following suggestions:—

First.—AS TO FREEZING.

If the two portals and the central shaft are left entirely open, it is to be presumed that, by reason of the strong draughts through, during the winter, the frost will reach many portions of the Tunnel, if not, indeed, the whole of it.

The brick masonry should not be exposed to freezing; for it never will be dry, but always saturated with water; and there are many portions of that which it is proposed to leave without masonry that will not bear freezing without eventually disturbing its stability. There will also be dangerous and troublesome accumulations of ice.

It will probably be necessary to arrange for a system of gates for the shaft and doors for the portals, to be operated during the winter by men in charge, having a local telegraph at their command. By these means the proper ventilation of the Tunnel in summer can also be secured.

Secondly.—AS TO TOP HEADINGS, AND THE USE OF NITRO-GLYCERINE THEREIN.

In prosecuting the work of building the Tunnel, between station 11274 east, and station 4055 west, a distance of 9,702 feet, the headings have been run mainly at the top. Nitro-glycerine has been used through this whole distance, and the simultaneous discharges of it have been gradually increased in quantity, till they reached the enormous amount of one hundred pounds at one firing. It cannot be doubted that these terrible explosions in the confined rock of the body of the mountain, and so near the top of the Tunnel, must have shattered the rock which forms the roof, causing some of it to fall away at the time, and leaving other portions of it insecure.

The positions of the heading through the entire Tunnel can be seen by referring to the profile.

It is necessary to consider *these facts* in determining the safety of the Tunnel.

Thirdly.—AS TO THE FORM OF THE TUNNEL ROOF.

The driving of the headings at the top was not favorable to a good shaped and stable roof.

It was no doubt intended that it should be finished in the form of a *flattened* arch, the centre of it being four feet below the line of a semi-circle.

It was almost impossible, however, to do this with a *top heading*. It was run, for the sake of speed and economy, the whole width of the Tunnel at its widest part, which was 24 feet, and sometimes more. Its floor must needs be about level: the men and machines must have at the sides not less than from six to seven feet in height in which to work; and, not being able to reach more than from eight to nine feet above the floor in the middle, the consequence is a very flat roof, with a span of from 24 to 30 feet, and a rise of from 0 to three or four feet only,—by no means a form of stability.

This is another fact which must be taken into consideration, and *which will continue in force* until the form of the roof be changed to a semi-circle, or to a gothic form, or until it be lined with masonary.

Its consideration is imperative in those portions of the mountain where the lines of stratification and cleavage lie nearly level.

The interests of the State would no doubt have been better secured had all the headings been driven at the bottom of the Tunnel, and had the semi-circular form been adopted for its roof.

Fourthly.—As to Influence of Air upon Walls and Roof of Tunnel.

There is very little chance that the opening of the mountain to the air will have any disintegrating or decomposing effect upon the rock, provided freezing be guarded against.

There are in the mountain many soft seams, both wet and dry, containing decomposed material, and varying in thickness from almost nothing to several feet. The opening of the Tunnel will permit, and the action of air and water will cause, the mechanical emptying of many of these seams, and, eventually, if nothing be done to prevent, the loosening of some of the rock; but it is believed that all these cases are provided for in the arching proposed.

Respectfully,

THOMAS DOANE.

Charlestown, Mass., Oct. 13, 1874.

SUMMARY OF REPORTS OF EXPERTS.

EAST OF CENTRAL SHAFT.

[Central Shaft is at Station 128+37 from the East.]

STATION TO STATION.	JAMES HALL.			T. STERRY HUNT.			JOSIAH BROWN.			D. L. HARRIS.			THOS. DOANE.		
	LINEAL FEET.			LINEAL FEET.			LINEAL FEET.			LINEAL FEET.			LINEAL FEET.		
	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.
0 to 50, . . .	50	–	–	50	–	–	50	–	–	50	–	–	–	50	–
50 to 925, . . .	875	–	–	875	–	–	875	–	–	875	–	–	875	–	–
925 to 975, . . .	–	50	–	50	–	–	50	–	–	50	–	–	50	–	–
975 to 1000, . . .	25	–	–	25	–	–	–	–	25	–	–	25	–	–	25
1000 to 1010, . . .	–	–	10	–	–	10	–	–	10	–	–	10	–	–	19
1010 to 1017, . . .	7	–	–	7	–	–	–	–	7	–	–	7	–	–	7
1017 to 1035, . . .	18	–	–	18	–	–	–	–	18	–	–	18	18	–	–
1035 to 1850, . . .	815	–	–	815	–	–	815	–	–	815	–	–	815	–	–
1850 to 2610, . . .	760	–	–	760	–	–	760	–	–	760	–	–	–	760	–
2610 to 2625, . . .	15	–	–	15	–	–	5	–	10	15	–	–	–	15	–
2625 to 3500, . . .	875	–	–	875	–	–	875	–	–	875	–	–	–	875	–
3500 to 4515, . . .	1015	–	–	1015	–	–	1015	–	–	1015	–	–	1015	–	–
4515 to 4525, . . .	–	–	10	–	–	10	10	–	–	10	–	–	10	–	–
4525 to 4590, . . .	65	–	–	65	–	–	65	–	–	65	–	–	65	–	–
4590 to 4600, . . .	–	10	–	10	–	–	–	–	10	10	–	–	10	–	–
4600 to 4840, . . .	240	–	–	240	–	–	240	–	–	240	–	–	240	–	–
4840 to 4850, . . .	–	–	10	–	–	10	10	–	–	–	–	10	–	–	10
4850 to 4860, . . .	–	–	10	–	–	10	–	–	10	–	–	10	–	–	10
4860 to 4870, . . .	10	–	–	10	–	–	–	–	10	–	–	10	–	–	10
4870 to 4875, . . .	5	–	–	5	–	–	–	–	5	2	–	3	5	–	–

4875 to 5043, . . .	168	–	–	168	–	–	168	–	–	168	–	–	168	–	–
5043 to 5063, . . .	–	20	–	–	–	20	–	–	20	–	–	20	–	–	20
5063 to 5710, . . .	647	–	–	647	–	–	647	–	–	647	–	–	647	–	–
5710 to 5720, . . .	10	–	–	10	–	–	–	–	10	10	–	–	10	–	–
5720 to 5737, . . .	17	–	–	17	–	–	17	–	–	–	–	17	–	–	17
5737 to 5809, . . .	72	–	–	72	–	–	72	–	–	72	–	–	72	–	–
5809 to 5819, . . .	10	–	–	10	–	–	–	–	10	10	–	–	10	–	–
5819 to 5858, . . .	–	–	39	39	–	–	39	–	–	39	–	–	39	–	–
5858 to 6380, . . .	522	–	–	522	–	–	522	–	–	522	–	–	522	–	–
6380 to 6400, . . .	20	–	–	20	–	–	–	–	20	20	–	–	20	–	–
6400 to 6600, . . .	200	–	–	200	–	–	200	–	–	200	–	–	200	–	–
6600 to 6640, . . .	–	40	–	40	–	–	40	–	–	–	–	40	–	–	40
6640 to 7310, . . .	670	–	–	670	–	–	670	–	–	670	–	–	670	–	–
7310 to 7350, . . .	–	–	40	40	–	–	40	–	–	40	–	–	40	–	–
7350 to 7425, . . .	75	–	–	75	–	–	75	–	–	75	–	–	75	–	–
7425 to 7475, . . .	50	–	–	50	–	–	–	–	50	–	–	50	50	–	–
7475 to 7640, . . .	165	–	–	165	–	–	165	–	–	165	–	–	165	–	–
7640 to 7650, . . .	10	–	–	–	–	10	–	–	10	10	–	–	10	–	–
7650 to 7660, . . .	10	–	–	–	–	10	–	–	10	–	–	10	–	–	10
7660 to 7670, . . .	10	–	–	10	–	–	10	–	–	–	–	10	–	–	10
7670 to 7680, . . .	10	–	–	10	–	–	10	–	–	10	–	–	10	–	–
7680 to 7690, . . .	–	–	10	10	–	–	10	–	–	10	–	–	10	–	–
7690 to 7710, . . .	20	–	–	20	–	–	20	–	–	20	–	–	20	–	–
7710 to 7720, . . .	–	–	10	10	–	–	10	–	–	10	–	–	10	–	–
7720 to 8000, . . .	280	–	–	280	–	–	280	–	–	280	–	–	280	–	–
8000 to 8075, . . .	75	–	–	75	–	–	–	–	75	75	–	–	75	–	–
8075 to 8100, . . .	–	–	25	25	–	–	–	–	25	25	–	–	25	–	–
8100 to 8115, . . .	–	–	15	–	–	15	–	–	15	–	–	15	–	–	15
8115 to 8125, . . .	–	–	10	–	–	10	10	–	–	–	–	10	–	–	10
8125 to 8425, . . .	300	–	–	300	–	–	300	–	–	300	–	–	300	–	–
8425 to 8440, . . .	–	–	15	–	–	15	–	–	15	–	–	15	–	–	15

Summary of Reports of Experts—Continued.

STATION TO STATION.	JAMES HALL.			T. STERRY HUNT.			JOSIAH BROWN.			D. L. HARRIS.			THOS. DOANE.		
	LINEAL FEET.			LINEAL FEET.			LINEAL FEET.			LINEAL FEET.			LINEAL FEET.		
	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.
8440 to 8535, . .	95	–	–	95	–	–	–	–	95	95	–	–	95	–	–
8535 to 8980, . .	445	–	–	445	–	–	445	–	–	445	–	–	445	–	–
8980 to 9000, . .	20	–	–	20	–	–	20	–	–	20	–	–	–	–	20
9000 to 9050, . .	–	–	50	25	–	25	50	–	–	–	–	50	–	–	50
9050 to 9150, . .	–	–	100	–	–	100	–	–	100	–	–	100	–	–	100
9150 to 9215, . .	–	–	65	65	–	–	–	–	65	–	–	65	–	–	65
9215 to 9220, . .	5	–	–	5	–	–	–	–	5	–	–	5	–	–	5
9220 to 9250, . .	30	–	–	30	–	–	–	–	30	30	–	–	30	–	–
9250 to 9550, . .	300	–	–	300	–	–	300	–	–	300	–	–	300	–	–
9550 to 9575, . .	25	–	–	25	–	–	–	–	25	–	–	25	25	–	–
9575 to 9725, . .	–	–	150	150	–	–	–	–	150	–	–	150	–	–	150
9725 to 9800, . .	–	75	–	75	–	–	75	–	–	–	–	75	75	–	–
9800 to 9810, . .	–	–	10	–	–	10	10	–	–	–	–	10	10	–	–
9810 to 9815, . .	–	–	5	–	–	5	–	–	5	–	–	5	5	–	–
9815 to 10800, . .	–	–	985	–	–	985	–	–	985	–	–	985	–	–	985
10800 to 10850, . .	–	50	–	–	–	50	–	–	50	–	–	50	–	–	50
10850 to 10900, . .	–	50	–	–	–	50	–	–	50	–	–	50	50	–	–
10900 to 11300, . .	–	–	400	–	–	400	–	–	400	400	–	–	400	–	–
11300 to 11325, . .	–	–	25	–	–	25	–	–	25	–	–	25	25	–	–
11325 to 11375, . .	–	–	50	–	–	50	–	–	50	–	–	50	–	–	50
11375 to 11385, . .	–	–	10	–	–	10	–	–	10	–	–	10	–	10	–
11385 to 11450, . .	–	–	65	65	–	–	–	–	65	–	–	65	–	65	–
11450 to 11700, . .	–	–	250	250	–	–	250	–	–	–	–	250	–	250	–

11700 to 11735,	–	–	35	35	–	–	–	–	35	–	–	35	–	35	–
11735 to 11825,	–	–	90	–	–	90	–	–	90	–	–	90	–	–	90
11825 to 11843,	–	–	18	18	–	–	–	–	18	–	–	18	–	–	18
11843 to 11850,	–	–	7	7	–	–	–	–	7	–	–	7	–	7	–
11850 to 11950,	–	–	100	100	–	–	100	–	–	–	–	100	–	100	–
11950 to 12000,	–	–	50	50	–	–	–	–	50	–	–	50	–	50	–
12000 to 12200,	–	–	200	200	–	–	200	–	–	–	–	200	–	200	–
12200 to 12250,	–	–	50	50	–	–	50	–	–	–	–	50	–	–	50
12250 to 12350,	–	–	100	–	–	100	100	–	–	–	–	100	–	–	100
12350 to 12650,	–	–	300	–	–	300	–	–	300	–	–	300	–	–	300
12650 to 12660,	–	–	10	–	–	10	10	–	–	–	–	10	–	–	10
12660 to 12700,	–	–	40	40	–	–	40	–	–	–	–	40	–	–	40
12700 to 12764,	–	–	64	–	–	64	–	–	64	–	–	64	–	–	64
12764 to 12837,	–	–	73	73	–	–	–	–	73	–	–	73	–	–	73
	9036	295	3506	10443	–	2394	9725	–	3112	9450	–	3387	7991	2417	2429

WEST OF CENTRAL SHAFT.

[Central Shaft is at Station 121+94 from the West.]

12194 to 12100,	94	–	–	94	–	–	–	–	94	–	–	94	–	–	94
12100 to 12050,	50	–	–	–	–	50	–	–	50	–	–	50	–	–	50
12050 to 12000,	50	–	–	–	–	50	–	–	50	–	–	50	–	–	50
12000 to 11950,	–	–	50	–	–	50	–	–	50	–	–	50	–	–	50
11950 to 11940,	–	–	10	10	–	–	–	–	10	–	–	10	–	–	10
11940 to 11900,	–	–	40	40	–	–	–	–	40	–	–	40	–	40	–
11900 to 11750,	–	–	150	100	–	50	–	–	150	–	–	150	–	150	–
11750 to 11500,	–	–	250	250	–	–	–	–	250	–	–	250	–	250	–
11500 to 11400,	–	–	100	–	–	100	–	–	100	–	–	100	–	100	–
11400 to 11300,	–	100	–	100	–	–	–	–	100	–	–	100	–	100	–

Summary of Reports of Experts—Continued.

STATION TO STATION.	JAMES HALL.			T. STERRY HUNT.			JOSIAH BROWN.			D. L. HARRIS.			THOS. DOANE.		
	LINEAL FEET.			LINEAL FEET.			LINEAL FEET.			LINEAL FEET.			LINEAL FEET.		
	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.
11300 to 11280, . .	–	–	20	20	–	–	–	–	20	–	–	20	–	20	–
11280 to 11250, . .	–	–	30	–	30	–	–	–	30	–	–	30	–	30	–
11250 to 11050, . .	–	–	200	200	–	–	–	–	200	–	–	200	–	200	–
11050 to 11030, . .	–	–	20	–	20	–	–	–	20	–	–	20	–	20	–
11030 to 10775, . .	–	–	255	–	255	–	–	–	255	–	–	255	–	–	255
10775 to 10650, . .	–	–	125	–	125	–	–	–	125	–	–	125	–	125	–
10650 to 10530, . .	–	–	120	–	120	–	–	–	120	–	–	120	–	–	120
10530 to 10525, . .	–	–	5	–	5	–	–	–	5	–	–	5	–	5	–
10525 to 10350, . .	–	–	175	175	–	–	–	–	175	–	–	175	–	175	–
10350 to 10335, . .	–	–	15	15	–	–	–	–	15	–	–	15	–	–	15
10335 to 10270, . .	–	–	65	–	–	65	–	–	65	–	–	65	–	–	65
10270 to 10260, . .	–	–	10	–	–	10	–	–	10	–	–	10	–	10	–
10260 to 10250, . .	–	–	10	10	–	–	–	–	10	–	–	10	–	10	–
10250 to 10150, . .	–	–	100	100	–	–	100	–	–	–	–	100	–	100	–
10150 to 10000, . .	–	150	–	150	–	–	150	–	–	–	–	150	–	150	–
10000 to 9750, . .	–	250	–	250	–	–	–	–	250	–	–	250	–	–	250
9750 to 9650, . .	–	100	–	100	–	–	100	–	–	–	–	100	–	–	100
9650 to 9600, . .	–	50	–	50	–	–	–	–	50	–	–	50	–	–	50
9600 to 9500, . .	–	–	100	100	–	–	–	–	100	–	–	100	–	–	100
9500 to 9420, . .	–	–	80	–	80	–	–	–	80	–	–	80	–	–	80
9420 to 9400, . .	–	–	20	–	20	–	20	–	–	–	–	20	–	–	20
9400 to 9350, . .	–	50	–	50	–	–	–	–	50	–	–	50	–	–	50
9350 to 9300, . .	–	50	–	50	–	–	50	–	–	–	–	50	–	–	50

9300 to 9210, . .	–	–	90	90	–	–	–	–	90	–	–	90	–	–	90
9210 to 9200, . .	–	–	10	–	–	10	–	–	10	–	–	10	–	–	10
9200 to 9100, . .	–	–	100	100	–	–	–	–	100	–	–	100	–	–	100
9100 to 9050, . .	–	–	50	–	–	50	–	–	50	–	–	50	–	–	50
9050 to 9030, . .	–	–	20	20	–	–	–	–	20	–	–	20	–	–	20
9030 to 8980, . .	–	–	50	50	–	–	50	–	–	–	–	50	–	–	50
8980 to 8950, . .	–	–	30	30	–	–	–	–	30	–	–	30	–	–	30
8950 to 8800, . .	150	–	–	150	–	–	–	–	150	–	–	150	–	–	150
8800 to 8780, . .	–	20	–	20	–	–	–	–	20	–	–	20	–	–	20
8780 to 8700, . .	–	80	–	80	–	–	80	–	–	–	–	80	–	–	80
8700 to 8603, . .	–	–	97	–	–	97	–	–	97	–	–	97	–	–	97
8603 to 8594, . .	–	–	9	6	–	3	–	–	9	9	–	–	9	–	–
8594 to 8556, . .	–	–	38	38	–	–	38	–	–	38	–	–	38	–	–
8556 to 8554, . .	–	–	2	2	–	–	–	–	2	2	–	–	2	–	–
8554 to 8525, . .	–	–	29	29	–	–	–	–	29	–	–	29	–	–	29
8525 to 8500, . .	–	–	25	25	–	–	25	–	–	–	–	25	–	–	25
8500 to 8460, . .	–	40	–	40	–	–	–	–	40	–	–	40	–	–	40
8460 to 8450, . .	–	10	–	10	–	–	10	–	–	–	–	10	–	–	10
8450 to 8000, . .	–	450	–	450	–	–	450	–	–	–	–	450	–	450	–
8000 to 7980, . .	–	20	–	20	–	–	–	–	20	–	–	20	–	20	–
7980 to 7800, . .	–	180	–	180	–	–	180	–	–	–	–	180	–	180	–
7800 to 7700, . .	–	–	100	100	–	–	–	–	100	–	–	100	–	–	100
7700 to 7400, . .	300	–	–	300	–	–	300	–	–	–	–	300	–	300	–
7400 to 7300, . .	–	100	–	100	–	–	–	–	100	–	–	100	–	100	–
7300 to 7200, . .	–	100	–	100	–	–	100	–	–	–	–	100	–	100	–
7200 to 7000, . .	–	–	200	–	–	200	–	–	200	–	–	200	–	–	200
7000 to 6975, . .	25	–	–	25	–	–	–	–	25	–	–	25	–	–	25
6975 to 6900, . .	75	–	–	75	–	–	75	–	–	–	–	75	–	–	75
6900 to 6700, . .	200	–	–	200	–	–	200	–	–	–	–	200	–	200	–
6700 to 6680, . .	–	20	–	–	–	20	20	–	–	–	–	20	–	–	20
6680 to 6650, . .	–	30	–	–	–	30	–	–	30	–	–	30	–	–	30

Summary of Reports of Experts—Concluded.

STATION TO STATION.	JAMES HALL.			T. STERRY HUNT.			JOSIAH BROWN.			D. L. HARRIS.			THOS. DOANE.		
	LINEAL FEET.			LINEAL FEET.			LINEAL FEET.			LINEAL FEET.			LINEAL FEET.		
	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.	Safe.	Trim.	Arch.
6650 to 6400, . . .	–	–	250	–	–	250	–	–	250	–	–	250	–	–	250
6400 to 6390, . . .	10	–	–	–	–	10	10	–	–	–	–	10	–	10	–
6390 to 6310, . . .	80	–	–	80	–	–	80	–	–	–	–	80	–	80	–
6310 to 4620, . . .	1690	–	–	1690	–	–	1690	–	–	1690	–	–	–	1690	–
4620 to 4575, . . .	–	–	45	45	–	–	45	–	–	45	–	–	–	45	–
4575 to 4510, . . .	–	–	65	65	–	–	–	–	65	65	–	–	–	65	–
4510 to 4400, . . .	–	110	–	110	–	–	–	–	110	110	–	–	–	110	–
4400 to 4365, . . .	–	35	–	35	–	–	35	–	–	35	–	–	–	35	–
4365 to 4350, . . .	–	15	–	15	–	–	15	–	–	–	–	15	–	15	–
4350 to 4325, . . .	–	25	–	–	–	25	–	–	25	–	–	25	–	25	–
4325 to 4305, . . .	–	–	20	–	–	20	–	–	20	–	–	20	–	20	–
4305 to 4251, . . .	–	–	54	–	–	54	–	–	54	–	–	54	–	–	54
4251 to 4192, . . .	–	–	59	58	–	1	58	–	1	59	–	–	59	–	–
4192 to 4180, . . .	–	–	12	12	–	–	12	–	–	–	–	12	–	–	12
4180 to 4100, . . .	–	–	80	80	–	–	–	–	80	–	–	80	–	–	80
4100 to 4050, . . .	–	–	$\frac{100}{2}$	–	–	50	–	–	50	–	–	50	–	–	50
4050 to 4000, . . .	–	–	–	50	–	–	–	–	50	–	–	50	–	–	50
4000 to 3975, . . .	25	–	–	25	–	–	–	–	25	–	–	25	–	25	–
3975 to 3550, . . .	405	–	20	425	–	–	425	–	–	–	–	425	–	425	–
3550 to 3500, . . .	–	–	50	50	–	–	50	–	–	–	–	50	–	–	50
3500 to 3120, . . .	–	–	380	–	–	380	–	–	380	–	–	380	–	–	380
3120 to 2800, . . .	–	90	230	–	–	320	–	–	320	–	–	320	–	320	–
2800 to 2753, . . .	–	47	–	–	–	47	–	–	47	–	–	47	–	47	–

2753 to 2750, . . .	–	3	–	3	–	–	–	–	3	–	–	3	–	3	–
2750 to 2700, . . .	–	–	50	50	–	–	–	–	50	–	–	50	–	50	–
2700 to 2530, . . .	–	75	95	–	–	170	–	–	170	–	–	170	–	–	170
2530 to 2457, . . .	–	–	73	–	–	73	–	–	73	–	–	73	–	73	–
2457 to 2447, . . .	–	–	10	–	–	10	–	–	10	–	–	10	–	–	10
2447 to 2360, . . .	87	–	–	87	–	–	87	–	–	87	–	–	–	–	87
2360 to — 50, . . .	2410*	–	–	2410*	–	–	2410*	–	–	2410*	–	–	2410*	–	–
West of Central Shaft, .	5651	2200	4393	9394	655	2195	6865	–	5379	4550	–	7694	2518	5873	3853
East of Central Shaft, .	9036	295	3506	10443	–	2394	9725	–	3112	9450	–	3387	7991	2417	2429
Total, . . .	14687	2495	7899	19837	655	4589	16590	–	8491	14000	–	11081	10509	8290	6282

* Already lined.

Table showing the Number of identical Lineal Feet of the Tunnel that all five Experts agree to be safe.

East of the Central Shaft.

STATION TO STATION.	Lineal Feet.	STATION TO STATION.	Lineal Feet.
50 to 925,	875	6640 to 7310,	670
1035 to 1850,	815	7350 to 7425,	75
3500 to 4515,	1015	7475 to 7640,	165
4525 to 4590,	65	7670 to 7680,	10
4600 to 4840,	240	7690 to 7710,	20
4870 to 5043,	170	7720 to 8000,	280
5063 to 5710,	647	8125 to 8425,	300
5737 to 5809,	72	8535 to 8980,	445
5858 to 6380,	522	9250 to 9550,	300
6400 to 6600,	200	East of Central Shaft,	6886

West of the Central Shaft.

12194 to 2360,	None.	2360 to —50,	*

* Already lined.

Table showing the Number of identical Lineal Feet of the Tunnel that all five Experts agree must be arched with brick.

EAST OF THE CENTRAL SHAFT.

STATION TO STATION.	Lineal Feet.	STATION TO STATION.	Lineal Feet.
1000 to 1010, . . .	10	10800 to 10850, . .	50
4850 to 4860, . . .	10	11325 to 11375, . .	50
5043 to 5063, . . .	20	11735 to 11825, . .	90
8100 to 8115, . . .	15	12350 to 12650, . .	300
8425 to 8440, . . .	15	12700 to 12764, . .	64
9050 to 9150, . . .	100	East of Central Shaft,	1709
9815 to 10800, . . .	985		

WEST OF THE CENTRAL SHAFT.

STATION TO STATION.	Lineal Feet.	STATION TO STATION.	Lineal Feet.
12000 to 11950, . .	50	4305 to 4251, . . .	54
11900 to 11750, . .	50	4100 to 4050, . . .	50
10335 to 10270, . .	65	3500 to 3120, . . .	380
9210 to 9200, . .	10	2700 to 2530, . . .	170
9100 to 9050, . .	50	2457 to 2447, . . .	10
8700 to 8603, . .	97	West of Central Shaft,	1466
7200 to 7000, . .	200	East of Central Shaft,	1709
6680 to 6650, . .	30		
6650 to 6400, . .	250	Total, . . .	3175

Table showing the Number of identical Lineal Feet of the Tunnel that any three or more Experts agree to be safe.

East of Central Shaft.

STATION TO STATION.	Lineal Feet.	STATION TO STATION.	Lineal Feet.
0 to 975, . . .	975	8125 to 8425, . . .	300
1017 to 4840, . . .	3823	8440 to 9000, . . .	560
4870 to 5043, . . .	173	9220 to 9575, . . .	355
5063 to 6600, . . .	1537	9725 to 9800, . . .	75
6640 to 7650, . . .	1010	East of Central Shaft, . .	9248
7660 to 8100, . . .	440		

West of Central Shaft.

8600 to 8554, . . .	46	3975 to 3550, . . .	405
7700 to 7400, . . .	300	2447 to —50, . .	2497*
6975 to 6700, . . .	275	West of Central Shaft, .	5396
6390 to 4575, . . .	1815	East of Central Shaft, .	9248
4250 to 4192, . . .	58	Total, . . .	14644

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* Already lined.

Table showing the Number of identical Lineal Feet of the Tunnel that three or more Experts agree must be lined with brick.

East of the Central Shaft.

STATION TO STATION.	Lineal Feet	STATION TO STATION.	Lineal Feet.
975 to 1017, . . .	42	9000 to 9220, . .	220
4840 to 4870, . . .	30	9575 to 9725, . .	150
5043 to 5063, . . .	20	9800 to 11450, . .	1650
6600 to 6640, . . .	40	11700 to 11850, . .	150
7650 to 7660, . . .	10	11950 to 12000, . .	50
8100 to 8125, . . .	25	12200 to 12837, . .	637
8425 to 8440, . . .	15	East of Central Shaft, .	3039

West of the Central Shaft.

12194 to 10250, . .	1944	4350 to 4251, . . .	99
10000 to 8603, . .	1397	4192 to 4000, . . .	192
8554 to 8450, . .	104	3550 to 2750, . . .	800
8000 to 7980, . .	20	2700 to 2447, . . .	253
7800 to 7700, . .	100	West of Central Shaft, .	5534
7400 to 7300, . .	100	East of Central Shaft, .	3039
7200 to 6975, . .	225	Total, . . .	8573
6700 to 6400, . .	300		

Explanation of the Profile.

The accompanying profile will show at a glance the summary of each expert's report. Each expert is given a line and on it his notes are plotted. In the reports of the experts, where the location of each particular portion of the Tunnel is not made by stations, the lengths designated have been given, and the location, for purposes of comparison, has been made the same as that of the majority of the other experts. Where the location has been given, but no length mentioned, the length designated by the majority of the others has been taken.

The stations are numbered from the east and from the west towards the central shaft, the station of that point being 128+37, or 12,837 feet from the east portal, and 121+94, or 12,194 feet from the west portal.

REPORT OF EDWARD S. PHILBRICK,

CONSULTING ENGINEER,

Made to the Governor and Council, July 31, 1874,

CONCERNING "HOW MUCH ARCHING WILL BE NECESSARY."

After carefully inspecting the whole length of the Hoosac Tunnel with Mr. B. D. Frost, my opinion is, that in addition to the amount included in the Shanly contract, as recognized by the Messrs. Shanly, and now under progress, there will be certainly required, for the safe passage of trains, a further amount of 1,600 feet of arching; while, for reasons given below, there is a still further length of 3,550 feet, concerning which I cannot now form a definite opinion. In regard to this, I can only say that it should be the subject of careful treatment and watching. The chances are that a large part of it—say upwards of one-third, and perhaps two-thirds—will also require to be arched, after other expedients shall have been tried and have failed. The nature of this doubt, and the proper means of removing it, will be better understood by my explaining the structure and condition of the rock, and the natural forces tending to its disintegration.

The arched lining is now either complete or in progress from the west portal to the west shaft, say half a mile, and the portion referred to in this Report will therefore extend from the east portal to the west shaft, about 4¼ miles.

Two causes contribute to this doubt; the unfinished condition of the contractor's work upon the roof, and the continual changes in the character of the rock in certain places, after its exposure.

First—as to the unfinished condition. While there remain only about 100 feet in length where any considerable enlargement is yet to be made, viz., directly east of the west shaft, there are scarcely six consecutive rods in length, through the whole work east of this point, where the roof is as yet stripped of its loose scales and masses that were shattered by the blasting. A very thorough and minute examination has recently been made by Mr. Frost and his assistants, of every part of the roof, accumulating a mass of records of great value for present and future guidance. This has been done by men on ladders or horses, moved along step by step, and by sounding the roof with light, long-handled hammers, while lighted by lamps held on long poles from the floor. This may seem to be a superficial test, but a good deal of this work has been done in my presence, and I am satisfied that it is the readiest and most reliable guide as a preliminary step; *i. e.*, I am satisfied that no mass or scale of rock, of the quality here existing, which would give a hollow sound to the hammer, would be safe to work under for any length of time; while any mass that yields a clear ring, and from which the hammer rebounds with vigor, is substantially safe for the present. A single examination of this kind has shown the general presence of loose material, as above stated. In many places, the scales seem thin, and are flanked by sound rock, while the appearance and structure of the mass is such as to justify the opinion that, after stripping such scales, we may find a self-suporting roof. This applies to a total length of about 17,000 feet in detached sections. In other places, the lack of soundness in the structure (*i. e.*, physical character) of the rock, or a more general degree of hollowness under the hammer, or both these conditions combined, lead us to doubt the possibility of attaining a permanently sound roof with any reasonable amount of stripping, while, so long as such a possibility exists, we should try such expedients as seem most likely to succeed. This applies to a total length of doubtful roof, referred to above, of 3,550 feet, in detached sections.

Second—The deterioration in the structure of the rock is mentioned as a element of doubt in deciding how far arching may be required. The rock, through the whole distance under consideration, is a compact mica-schist, presenting a considerable variety of structure, though by no means a *soft* rock anywhere. Its weakness arises from the veins of talc and feldspar which intersect it at intervals, and the numerous seams or joints, mostly west of the central shaft, cutting the mass into detached blocks, having little or no cohesion with one another, and carrying large quantities of water, which percolates from the surface of the mountain. The solvent power of water, acting on the sides of the crevices through which it percolates, is an important agent of change, for there are but few known minerals absolutely insoluble in water to some extent, and however small the quantity so dissolved by any one drop or gallon, the flow of water is perennial, being ever renewed by the rainfall at the surface. Although the percolating water may be supposed to become saturated with the minerals through which it passes long before arriving at the Tunnel-roof, the exposure to the air and acid gases there present may give it new solvent powers by which it is constantly working upon the very strata with which we have to deal; viz., those forming the roof of the Tunnel itself.

I have spoken of talc as a source of trouble. Where it occurs in large masses, as it did for the first thousand feet at the west end of the Tunnel, its rapid decomposition upon exposure has become familiar to all who had to do with the earlier stages of the work. But talc also occurs through the whole Tunnel, in veins varying in thickness from an impalpable film to twenty or thirty feet. These latter must, of course, be arched, having been timbered up at once on their exposure. The veins of intermediate thickness sometimes discharge their contents into the Tunnel, so that a fishing-rod can be run up for twenty feet above the roof where the crack is but two inches wide. Little inconvenience might result from this if such veins were detached and parallel, as they generally are in the eastern section, where they are found dipping eastward, with a strike nearly at right angles to the axis of the Tunnel.

They are here normal to the foliated structure of the schist, which is quite pronounced and uniform. But under the principal axis of the mountain-chain, possibly an anticlinal axis of upheaval, west of the central shaft, the case is widely different. The mass of the rock is still a hard schist and very refractory, but the foliation is slightly pronounced, while the veins of talc and feldspar occur in all conceivable directions, cutting through the structure and leaving between them blocks of all sizes with but little cohesion between each other, their surfaces being lubricated by the slimy paste of the decomposed vein. The decomposition of the veins of feldspar is rapid in many places in the Tunnel, where its pure, flesh-colored crystals have turned to kaolin and run into the ditch, while apparently similar crystals, exposed for months on the spoil-bank outside, are yet sound. Perhaps this decay inside the Tunnel may have been caused by fumes of sulphurous and nitrous acid from the burning of explosives. This will soon cease, but the coal-smoke from locomotives also contains such gases, and may keep the supply good in future.

Where the thickness of these veins is so slight as to be barely perceptible, the amount of cohesion between their sides is very uncertain. It is only by close watching and the lapse of time, after stripping, that their presence to an injurious extent can be decided upon. A careful record has been kept of all these doubtful places, and all changes carefully noted. A careful comparison with future observations will do much towards forming a reasonable opinion as to what must be done to make safe work in these parts of the Tunnel. I would here call attention to the fact that any opinions here expressed as to the probable soundness of the 17,000 feet, are based upon present light, and that it is quite impossible to predict what changes may occur hereafter through the decomposition of veins not yet apparent. But besides the doubtful places, there still remains a long list of other points where the character of the rock is manifestly unsafe, as ascertained since the enlargement, not only by repeated examinations as to its physical structure and the changes at work therein, but by the repeated falls which are on record. This makes up the length of 1,600 feet named above, where I consider arching to be clearly indispensable.

The stripping of the loose material from all those portions of the roof where arching is not considered absolutely necessary is a work of no small importance, not only for the parts thereby rendered safe, but as a necessary step in determining exactly how much can be so left without artificial support. This work is, I understand, to be begun at once. Nothing of importance has hitherto been done towards it, for lack of men and apparatus. Men are now being relieved at other points, but the apparatus may be lacking unless new stages be made. An attempt was recently made to remove the scales from about 1,000 feet of the roof in the western section (between stations 8600 and 9600), but the work was so imperfectly done that the whole ground must be again worked over, as proved by subsequent examination. This is a work requiring no small degree of skill and thoroughness to insure success, and no small degree of caution to guard against injury to the men employed. Most of the loose material may be detached by bars or wedges, but in many places light blasting will be required. From all the information I can obtain, I think a gang of men, with a suitable carriage or stage travelling on wheels, can work over an average of 1,000 feet per month, if worked three shifts per day. There being about 20,500 feet to work over, three full triple gangs will thus require about seven months to accomplish the whole, or six full gangs may do it in three and a half months, if supplied with apparatus.

The time to be required in arching the 1,600 feet considered certainly necessary, will depend, in great measure, upon the vigor and ability of the men who undertake it. The laying of the brick and lining of the space between arch and rock will take less time than the excavation to make room for them. After consulting with Mr. Shanly, I am inclined to think that, by working three shifts, one gang can complete an average of 100 feet per month. The removal of the debris will limit the number of points of attack to four at first; and afterwards, to three and two. An average of three gangs, working three shifts, may possibly finish the 1,600 feet in five or six months, but it will be difficult to attain this.

The *form of arch* fixed upon some years since for use in the western end, was very well devised for the conditions then existing, but we have now to deal with different conditions, and I would recommend a change by which some cost may be saved, and equal security attained. The rock we now have to deal with is not likely to trouble us by lateral pressure, and I would therefore build the side walls plumb below the springing line of the arch, keeping the full width of twenty-six feet in clear to the bottom. Also, I would not deem it worth while to excavate for foundation below the rock floor or grade line. If suitable building-stone could be readily got, I should advise in this connection, the use of stone in place of brick for the lower four or five feet. Stone would be less likely to be abraded by wear, through contact with tools and materials used in track repairs. But the cost of getting suitable stone from quarries for the purpose would exceed the cost of brick, while the stone found in the Tunnel is too shapeless and too refractory under tools, to admit of its being used with propriety. The possibility of starting the brick arch from a shoulder or offset to be cut in the rock several feet above the floor, has also engaged my attention. It is, doubtless, feasible; but the cost of making such a shoulder, which should present a surface *not sloping down* towards the centre of the Tunnel, so as to form a stable bearing, without at the same time shattering the material directly under it, on which the weight would be imposed, would, in my opinion, be greater than the cost of blasting out and beginning at the floor. If the rock wall was of a less refractory material, such as limestone or sandstone, or if horizontally stratified by nature, such a process would be comparatively cheap; but, with the materials nature has placed there, a large amount of hand-picking would be necessary to secure a sound shoulder, making the process very costly.

In view of facilitating the progress of the arching, by bringing brick, by rail, from Greenfield, I would suggest the propriety of making provision at once for a track from the end of the present tracks to the Tunnel, over the rock embankment, at the east end, and the ballasting of the same with gravel.

Respectfully submitted by,
Your obedient servant,

EDWARD S. PHILBRICK,
Consulting Engineer.

[B.]

REPORT OF GEO. S. MORISON,

Civil Engineer,

ON THE ROUTES BETWEEN NORTH ADAMS AND POINTS IN THE STATE OF NEW YORK.

[Referred to in the Report, Pages 17-19.]

Hon. W. B. Washburn, *President Boston, Hoosac Tunnel & Western Railroad Corporation.*

Dear Sir:—In August last I was requested by Mr. Charles F. Adams, Jr., in behalf of your corporation, to make a general examination of the country west of the Hoosac Mountain, and to report upon the merits of the several routes from the Hoosac Tunnel to the Hudson River, or to a connection with the New York Central and the Albany & Susquehanna railroads, the projected routes for a line to Lake Ontario independent of any now existing, and the several lines of water communication from which your railroad might hope to derive traffic.

About the 1st of September I visited Albany and North Adams, and made a cursory examination of the country, with a view to determining what course my more careful examinations should take. On this occasion I went on foot through the Hancock valley, between Williamstown and Stephentown. I also visited Oneida County, and ascertained where the governing points on the projected extension to Lake Ontario were to be found. On my return, I sent out an assistant, who took copies of county maps and of such other records as would be of value in examining the country.

In the latter part of the same month I again visited Albany, and on this occasion, finding that the Boston, Hoosac Tunnel & Albany Railroad Company, a New York organization, under the management of Col. C. Adams Stevens, had just begun a survey of its projected route to Petersburgh, and recognizing this line as more likely to prove feasible than the more southerly lines, at Col. Stevens' request I at once placed a man in the party, who took charge of the level and whose notes enabled me to verify the results of the survey.

In the early part of October, my assistant having collected all the maps and records required, I sent out another man to work with him, and had a careful barometrical examination made of the ruling summits between the Hoosac and Hudson rivers, and between the Mohawk and the Sacondaga, in Saratoga County. This examination was made with the United States standard mercurial barometers, and was also extended to Piseco Lake and the head-waters of the Sacondaga.

Finding much doubt expressed as to the grades of the Troy & Boston railroad, I had a line of levels run from the Union Depot at Troy to the summit west of Schaghticoke. The result of these levels was to confirm the general features of the recorded profiles; the ruling grades of this line being forty feet in a mile.

About the middle of October, the necessary amount of preliminary information having been collected, I made my final visit into this country, and a more thorough personal examination. With Col. Stevens I drove over the northern part of Rensselaer County, examining not only the line proposed for his railroad, but the range of hills west of Petersburgh for several miles in both directions. I also went to Schaghticoke and examined the country between there and the Hudson River, crossed the river at Stillwater and went down to Mechanicville, noting the features of country which would govern the location of a line crossing the Hudson in this neighborhood. From Mechanicville I went to Ballston, going on foot over the country between the two lines of the Rensselaer & Saratoga railroad, and thence drove across the country to Johnstown, finding the character of the country such that the features of a line through it were readily determined. From Johnstown I went by rail to Rome, and on this occasion also visited Booneville and drove about nine miles west of the town, to the neighborhood of the summit on the projected railroad line to Port Ontario. From Booneville I returned as far as Trenton Falls, and in company with Mr. Stryker, of Rome, who was engaged in the survey of the Boston, Rome & Oswego railroad, I drove across Herkimer County, making a careful examination of the several summits between the two Canada creeks. At the east line of the county, I was joined by Mr. H. R. Snyder, of Johnstown, with whom I went over the western part of Fulton County, and whose general knowledge of the country, as well as his more special acquaintance with the surveys made by him for the Atlantic & Ontario railroad, were of great assistance to me. In these examinations I carried an aneroid barometer and copies of county maps, which enabled me to follow the several proposed routes, and to check roughly the notes and elevations which had been furnished me.

I have also examined the records of the surveys of the Albany, Sand Lake & Stephentown railroad line, and the survey made through the same country under the direction of Mr. Bingham of Albany; of the Williamstown & Hancock railroad line; of the Boston, Rome & Oswego railroad line, and of the survey from Salisbury, near the east line of Fulton County, north-westerly towards Booneville.

My examinations were conducted throughout with a view to determining the ruling features and governing points of the country, the local details which will come up when any of these lines are built being given comparatively small attention. It was my object to find out what could be done in the several general locations considered, rather than to review the special faults and merits of lines actually surveyed.

In the pages below are described separately the three different subjects covered by my examination, viz. :—

1. The several routes from the Hoosac Tunnel to Albany, Troy, or some other point where a connection can be made with existing railroad lines to the West.

2. The railroad lines to the West, whether now in operation or projected, which the Tunnel railroad may look to making a connection with.

3. The lines of transportation by water from which the Tunnel railroad may derive traffic.

I. RAILROAD ROUTES WEST FROM THE HOOSAC TUNNEL.

Character of Country.

The country which a line built west from the Hoosac Tunnel must traverse is a rugged mountain region, with a north and south local drainage. There are three parallel ranges of hills west of the Hoosac Mountain, through which mountain the Tunnel has been bored, each range terminating on the north at the valley of the Hoosick River. The first range terminates between North Adams and Williamstown; the second range terminates at Petersburgh junction, and the third range in the town of Hoosick, near Eagle Bridge station. Between the Hoosac Mountain and the first range lies the valley through which the Pittsfield & North Adams railroad is built, the summit in the valley being but a short distance north of Pittsfield. Between the first and second ranges lies what is known as the Hancock valley, which drains north and south from a summit in the northern part of the town of Hancock. Between the second and third ranges lies the valley in which the Harlem Extension railroad is built, the valley draining north and south from a summit in Berlin township; this valley and the one last described come together on the south, in the township of Stephentown and their southward drainage is into Kinderhook Creek. West of the third range of hills lies a broken country sloping towards the Hudson.

The first and second ranges are too abrupt and high to think of crossing them with a railroad line. The third range terminates on the south near the south line of Rensselaer County, where Kinderhook Creek runs around it; from opposite Stephentown north as far as North Petersburgh its elevation continues at least 1,500 feet above tide-water, it then falls off somewhat and the gaps are not more than 1,000 feet high.

The valley of the Hoosick River passing around these several ranges of hills forms a natural railroad route from the Tunnel west; no line can be found out of this valley without passing over the summit from one water-shed to another. A line extended due west from the Tunnel would pass about midway between Albany and Troy, but the Troy & Boston railroad, following the general course of the Hoosick River, is driven 16 miles north of such due west course.

Any approach to an air-line west is impossible, the second range of hills is everywhere impassable, and the third range can only be crossed south of Stephentown or north of Petersburgh, the southern limit being 12 miles south of the due west course from the Tunnel and the northern limit 8½ miles north of such course.

Routes to Albany.

Two routes have been proposed for a direct line from the Hoosac Tunnel to Albany, one passing north and one south of the impassable portion of the third range of hills.

Hancock and Stephentown Route.

The first follows the Hancock valley, above described, from Williamstown to Stephentown, where it crosses the Harlem Extension railroad and thence goes across the country to Albany. It connects with the Troy & Greenfield railroad about one mile east of Williamstown, and the distance from this point of junction to Albany is 47.5 miles, making the distance from North Adams to Albany 51 miles, and from Boston to Albany 194 miles, or 7 miles less than the Boston & Albany railroad.

The Massachusetts portion of this line is covered by the Williamstown & Hancock railroad organization, of which Mr. Mills of South Williamstown is president. Two surveys have been made of the New York portion of the line, one by Mr. Robert F. Ewing, and one under the direction of Mr. Bingham, engineer of the city of Albany. The survey of the route from Williamstown to Stephentown shows a line laid in the bottom of the valley which could be very cheaply constructed; but though the valley is so level as to afford an excellent line for a highway, the summit is really 1,215 feet above tide-water, the ascent from Williamstown being 625 feet in 11 miles and the descent to Stephentown 347 feet in 6.2 miles. By keeping on the side of the valley and encountering some heavy work the grades can be averaged and reduced to about 55 feet per mile, ascending eastward. The survey shows grades exceeding 80 feet per mile in each direction. The summit is a fixed fact, which can neither be avoided nor tunnelled.

The New York portion of the line runs across the drainage of the country, passing over a summit 1,070 feet above tide-water, 8 miles west of Stephentown, and encountering very heavy and expensive work for nearly the whole distance. The surveys show grades of 60 and 80 feet per mile, ascending eastward. The average grade would be 50 feet per mile for 22 miles, but it is not probable that a line could be found on which an average grade could be constructed. By following the valley of the Kinderhook to Chatham, the summit west of Stephentown could be avoided. This, however, would increase the distance nearly 10 miles, and make the western 20 miles of the line almost identical with that of the Boston & Albany railroad.

Stevens Route.

The second route for a direct line to Albany follows the course of the Hoosick River as far as Petersburgh Junction, thereby passing around the first two ranges of parallel hills, and leaving the valley so far north that the gaps in the third range have become comparatively low.

This line has recently been surveyed by the Boston, Hoosac Tunnel & Albany Railroad Company, and is now known as the Stevens route. The summit is crossed at a point known as Potter Hill. The highest elevation on the line is 1,000 feet above tide-water; but the slope at first is rapid in both directions, and by using a tunnel 3,500 feet long the elevation is reduced to 850 feet. The ascent from Petersburgh to this tunnel will be by a line on the slope of the mountain. This piece of work would require great care in the location, and would be heavy and expensive in construction. The surveys here show a grade of 70 feet per mile, ascending westward; but it is believed that by passing around the head of a ravine, sufficient distance can be obtained to reduce this grade to 60 feet, and, possibly, to less. From the tunnel the line proceeds westward towards Troy. It passes through an excellent farming country, the direction of the natural drainage is favorable, and much of this portion of the line can be cheaply constructed. The line enters the corporation limits of the city of Troy, passing near the village of Albia, and being there over 300 feet above tide-water. It then turns southward, and fitted on the declivity of the slope towards the Hudson, descends with a grade of 40 feet per mile to a point on the east side of the Hudson near the Albany and Greenbush ferry landing, where it is proposed to cross the river on a new bridge and at an elevation of 40 feet. This line can be built with no grade exceeding 40 feet per mile, ascending eastward. The work east of the tunnel and on the four miles nearest to Albany, will be of a heavy and expensive character; elsewhere the difficulties of construction are small.

A connection can be made with the Hudson River railroad, below Greenbush, with a 40-feet grade. A direct connection with either of the present bridges could not be made without using a heavier grade.

The length of this line from Petersburgh to Albany is 32 miles, making the distance from North Adams 48 miles, and from Boston 191 miles, being 3 miles shorter than the Hancock route, and 10 miles less than by the Boston & Albany railroad. Between North Adams and Albany the ascent westward is 356 feet, and the ascent eastward 1,030 feet.

There is a summit a mile north of Potter Hill, the elevation of which is only 910 feet. The old Boston stage road passes through this gap, and it is possible that it would prove the best location for a railroad. The approaches, however, are not so good as those to Potter Hill, and the summit is too broad to make tunnelling expedient.

This line to Albany has merit, but it involves an ascent of 356 feet, and, of course, an equal descent, which is entirely avoided by a line following the Hoosick valley; a circumstance of little importance to a road having only a local traffic, but a serious disadvantage to a trunk freight line.

Troy & Boston Railroad.

The route from the Hoosac Tunnel to Troy is by the Troy & Boston Railroad; distance from North Adams 48 miles, from Boston 191 miles. Ascent westward from North Adams 111 feet; ascent eastward, 785 feet.

This road was constructed nearly twenty years ago. It follows the general course of the Hoosick River for 35 miles to a point near Schaghticoke, where the river turns northward and the railroad bears southward; ascends to the divide between the Hoosick and the Hudson River, and after attaining a summit 355 feet above tide-water, descends to the city of Troy. Its maximum grade ascending eastward is 40 feet per mile, except for a very short distance in the city. The general route of this road was well selected, but the details of the location were not so good. Too much value was evidently attached to alignment, and the road, on which no other grades were required than those corresponding to the natural fall of the river, is a line of undulating character with short grades in both directions. At least 100 feet of ascent and an equal amount of descent could have been avoided by keeping the line a little further north. The abandoned road-bed of the Albany Northern railroad, though also defective in detail, is on better ground than the Troy & Boston railroad.

The Troy & Boston railroad is a single-track line, in fair order for local traffic. Its weak point seems to be its structures, many of which are old and poor.

Both Albany and Troy are on the navigable part of the Hudson, the ebb and flow of the tide reaching the latter place. At each point the river is crossed on a drawbridge and at an absolute height no greater than that of the bridge itself.

Line to Schenectady.

The Hoosick River enters the Hudson at Stillwater, 14 miles above Troy. From North Adams to Schaghticoke, six miles from Stillwater, the fall of the river is about 420 feet, an average of 12 feet per mile of valley. Within two miles below Schaghticoke, the river falls about 200 feet. At Mechanicville, three miles below Stillwater, a creek enters the Hudson from the west.

The old Albany Northern railroad was built in the Hoosick valley from Eagle Bridge to Schaghticoke; it lay north of the

Troy & Boston railraod and nearer the river. It passed directly through the village of Schaghticoke, crossing the river twice in that immediate neighborhood, being there 289 feet above tide-water, or 81 feet lower than the corresponding point on the Troy & Boston railroad. The three miles west of Schaghticoke were a succession of very heavy cuttings and embankments, and in this distance the road descended 45 feet; it then reached the side slope of the Hudson River valley and curving southward descended into the valley and crossed the river 7 miles above Troy at an elevation of 45 feet above high-water.

Between Mechanicville and Stillwater the Hudson River is very shallow and the bottom is of solid rock, the bed being in the neighborhood of 55 feet above tide-water, and high-water mark being at least 20 feet higher.

About midway between the two villages comparatively high ground approaches the river on each side, and the river could be crossed on a deck bridge, without unreasonable expense at an elevation of 130 feet above tide-water, this crossing taking the railroad very conveniently over the Champlain Canal which lies near the west bank of the river, and is 100 feet above tide-water. The descent from the old Albany Northern grade at Schaghticoke to this bridge would be 160 feet, and the distance is a little over 6 miles, so that the descent could be accomplished with a grade of 1 in 200 or 26.4 feet per mile, which is the grade adopted in the Hoosac Tunnel, from each end to the central shaft.

The track of the Rensselaer & Saratoga railroad is 106 feet above tide-water, where it crosses the Champlain Canal at Mechanicville, and it follows up the valley of the small creek mentioned above to Ballston, with no grade exceeding 26.4 feet per mile. Five miles above Mechanicville a branch enters this creek from the south-west; the summit between this branch and the Mohawk is only 310 feet above tide-water and the descent in each direction can be accomplished with light work and very easy grades, the summit being about eleven miles from the Hudson River, and eight miles from Schenectady. By this route the distance from Schaghticoke to Schenectady will certainly not exceed 26 miles, making the total distance from North Adams to Schenectady 61 miles, and from Boston to Schenectady 204 miles. The distance from Boston to Saratoga Springs by this route would be only 205 miles. The only necessary ascent westward is from the Hudson River to the summit near Schenectady amounting to 195 feet, and the ascent eastward from Schenectady to North Adams need be only 653 feet. By way of Albany and the "Stevens route" the ascents between Schenectady and North Adams are 677 feet westward and 1,135 feet eastward, and by way of Troy and the Troy & Boston Railroad 446 feet westward and 904 feet eastward.

This line, by way of Schaghticoke and Mechanicville, can be built with no grade exceeding 26.4 feet per mile in either direction, though, as there are nearly 2.5 continuous miles of this grade in the Tunnel, where resistances are greater than in the open air, economy of construction might be fostered, without increasing the expense of operation, by using 30-feet grades. This grade should in my opinion be rigidly adhered to as the ruling maximum eastward grade, on that portion of the Tunnel line which lies west of the Connecticut River, the capacity of a locomotive on a 30-feet grade being fully 20 per cent. more than on a 40-feet grade. The grade which it would appear most difficult to avoid is the 42-feet grade between North Adams and the Tunnel, but this can easily be reduced by building about 2½ miles of single-track loop-line for east-bound freight trains.

Above Eagle Bridge the valley of the Hoosick River is narrow, and it would be troublesome, though not impossible, to locate a second line in the same valley. Below Eagle Bridge the Troy & Boston railroad is too far from the river, and a much better line can be found north of it. From Schaghticoke to the crossing of the Hudson River above Mechanicville, the line must be fitted to the steep slope of the valley, and the work would be very heavy; but by following the Albany Northern grade for three miles, the heaviest part of the work would be found already done. The Hudson River at the place of crossing is not far from 800 feet wide, and the cost of a bridge would not exceed $250,000, this amount covering the cost of a first-class double track, iron deck bridge, extending from bank to bank, and with masonry of such height as to place the base of rail seventy-five feet above the bed of the stream. From the Hudson River to Schenectady, the work is all of light and inexpensive character.

The connection with both the New York Central railroad and the lines of the Delaware and Hudson Canal Company, could be made on the north side of the Mohawk, where abundant space is afforded for yard room, and the expense of a bridge across the Mohawk would be saved.

The number of miles of new road required to be built to complete this line, assuming the Troy & Boston railroad to be used above Eagle Bridge, would be thirty-seven.

Comparison of Routes.

The distances by the three routes discussed appear from the following table:—

LOCALITY.	From Boston.	From Buffalo.	From Binghamton.	Boston to Buffalo.	Boston to Binghamton.
Albany, . . .	191	298	142	489	333
Troy, . .	191	302	149	493	340
Schenectady, .	204	281	130	485	334

Showing a difference in favor of Schenectady of four miles over Albany, and of eight miles over Troy, to all points reached by the N. Y. C. R. R., and a difference against Schenectady of one mile in favor of Albany, and a difference in favor of Schenectady of six miles against Troy to all points reached via Binghamton and the Erie railway. The gradients and the ascents and descents, however, make a much stronger showing in favor of Schenectady than is made by the distances alone. The Schenectady line has also the advantage of escaping the tolls which are charged for crossing the bridges at Albany and Troy, and the charges of the Troy Union Railroad Company in the city of Troy, and it terminates at a point where ample space can be had in the most convenient location for yards and transfer houses. On the Albany line, there is no suitable ground for this purpose, excepting on the flats south of the city, and at Troy the only available space is on Green Island, west of the river.

The value of a terminus at a large city should not be underrated. It is, however, of much more value to a local passenger business than to a heavy freight traffic, and would be of little consequence to the through business which the Tunnel route is expected to bring into Massachusetts. But it is of the utmost importance to the economical transfer of freight from one road to another, that the junction be made at a point where large yards, with abundant side tracks and convenient access can be laid out. Freight coming through Albany and Troy is hampered by having to pass through narrow streets, and yards can be built only in out-of-the-way localities; circumstances which contrast severely with the liberal arrangements which would be perfected on the north side of the Mohawk, near Schenectady.

At Buffalo, the interchange of freight and passengers between the several railroads centering there, was formerly made in the city. Of late years, however, this course has been changed. The Erie railway purchased over two hundred acres of land at East Buffalo, outside of the city, and there established an extensive yard where freight trains are made up. The New York Central railroad has also built an East Buffalo yard, lying immediately north of that of the Erie railway, where its exchange of freight is conducted, and its trains are made up. Lately a union passenger station has been erected on these grounds, in which the passenger trains of the New York Central railroad and the Lake Shore & Michigan Southern railway make their connections.

Half a century ago it was observed that nature had marked out the neighborhood of the forty-third parallel as its chosen transportation route between the East and the West. In New York State the Mohawk valley broke through the mountain range which divided the basin of the great lakes from the Atlantic slope. East of the Hudson the valleys of the Hoosick and the Deerfield rivers prolonged the line. In western Massachusetts the valleys of these two rivers approached within five miles of each other, but between them rose the lofty barrier of the Hoosac Mountain. The Mohawk valley was early occupied by the Erie Canal, and, in later years, the Utica & Schenectady railroad, now part of the New York

Central railroad, followed the same route. In 1825 a canal line was surveyed through the Hoosick and Deerfield valleys, and a tunnel proposed through the Hoosac Mountain, but the difficulties of construction were too great, and the canal east of the Hudson was never built.

To-day, after many years' delay, the Tunnel has been completed, and the only barrier in the line of the natural valleys between the Connecticut River and the great lakes has been removed. The object of the Tunnel was to complete the line which nature had marked out, and this line was down the Hoosick valley to the Hudson. Other lines may be found, but they are of artificial character, running over elevated summits, requiring powerful machinery for their operation, and encountering west of the Tunnel obstacles of the very class which the Tunnel was built to overcome: in brief, by leaving the valley of the Hoosick River the line of nature is abandoned and the one possible low grade line between the Connecticut and the Hudson is thrown away.

The falls of the Mohawk at Cohoes and of the Hoosick at Schaghticoke are obstructions which canals must overcome with heavy lockage, but which a railroad line can overcome more easily, by crossing the Hudson at an elevation and taking advantage of the comparatively level character of the country in the south-east part of Saratoga County. By the same course the loss of distance occasioned by the bends of the Mohawk below Schenectady is avoided, and the line on which the grades are the lightest is also the most direct.

The Schenectady route has the further merit of lying north of all other lines, and so being in a position to take advantage of the business which must one day be developed in the spruce forests and the rich iron regions of north-eastern New York. The Adirondack railroad already penetrates this district, and is expected ultimately to reach Lake Ontario near the entrance to the St. Lawrence. An east and west line north of the Mohawk valley has been proposed as an independent western route in the interests of Boston. Such a line could be built at any time as a branch of the road to Schenectady, and the power to construct such a rival road might be more valuable if used as a means of forcing favorable arrangements with existing lines, than would be the ownership of the completed line.

In brief, the construction of the line striking the Mohawk at Schenectady would appear to have the strategic merit of making the Tunnel route, under all circumstances, the independent master of its surroundings.

II. Railroad Connections to the West.

Connections with Existing Railroads.

The two all-rail routes to the West, which the Tunnel road can look for an immediate connection with, are by way of the New York Central railroad and of the Erie railway, the latter being reached through the Albany & Susquehanna railroad. The former, running almost directly west with a four-track line, will soon be in a condition to supply all the business which can be handled by both the Boston & Albany and Tunnel railroads. The latter, though less direct, is not so long but what it will be of great value as a competing line, and it finds its shortest route to Boston and the interior of Massachusetts by this line, it being seventy miles shorter than the route via Newburgh and the Boston, Hartford & Erie railroad. There are four focal points through one of which the New York Central and Erie railway routes to nearly every part of the West must pass. These are Buffalo, Detroit, Cincinnati and Indianapolis; and the distance from Boston to each of these points, via Schenectady and the N. Y. C. R. R. and via the Erie railway, by both routes, appears from the following tables:—

BOSTON TO—	N. Y. C. RAILR'D.	ERIE RAILWAY.	
	Via Schenectady.	Via Schenectady.	Via Newburgh.
Buffalo, ...	485	542	613
Detroit, ...	721	794	865
Cincinnati, ...	912	983	1,052
Indianapolis, ...	950	1,019	1,090

An extension of the Albany & Susquehanna railroad from Binghamton to Canton on the Northern Central railway is proposed. Such an extension will open direct communication with the great Pennsylvania railroad system and bring Pittsburg and the railways centering there into connection with the Tunnel route.

Connection with Coal Mines.

The Albany & Susquehanna railroad, in the hands of the Delaware & Hudson Canal Company, is used principally as a line to distribute that company's coal, the distance from Schenectady to Carbondale, where the mines are situated, by way of the cut-off from Nineveh and the Jefferson Branch of the Erie railway, being 159 miles, making the distance from Boston 363 miles.

The distance from Boston to Carbondale, via the B. H. & E. R. R. to Newburgh, the Erie railway to Honesdale, and the Delaware and Hudson Canal Company's gravity roads from that point, is 344 miles.

Besides the lines already existing, two new railways to the West have been proposed with which the Tunnel line would make connections.

New York West Shore & Chicago Railroad.

The first of these is the New York, West Shore & Chicago railroad, the line of which has been located from Hoboken to the International Bridge at Buffalo, following the west bank of the Hudson to Catskill, striking the Mohawk at Schenectady, following up the south bank of that river to Utica, and thence running by nearly an air-line to Buffalo, the whole line being located with no grade exceeding twenty feet per mile eastward, nor thirty feet westward. But little work has been done on this road, and its construction would not seem to be very probable. Should it ever be built, the Tunnel route could connect with it without difficulty at Schenectady. Connection could also be made at Albany, to which point the West Shore Company proposed to build a branch.

A similar line has recently been advocated as a route to Lake Ontario, by Mr. George I. Post, of Fair Haven, N. Y.

The line he proposes would follow the south bank of the Mohawk to Rome, and beyond that point be identical with the route of the Boston, Rome & Ontario railroad. The grades on this line would be nearly perfect, and it has merit.

Independent Line North of Mohawk Valley.

The second proposed line is a line lying north of the New York Central railroad, and extending from the Hudson River to some point on Lake Ontario. This line has been advocated especially as an independent western outlet for the Tunnel line.

It has been more or less talked of for many years. It was proposed and surveyed a quarter of a century ago, under the name of the Troy & Oswego railroad. More recently it has been revived by residents of the towns through which it runs, and organizations have been formed for its construction. The principal of them are the Boston, Rome & Oswego Railroad Company, the western terminus of which is made at North Bay, on Oneida Lake, where a connection with the New York & Oswego Midland railroad is proposed; and the Atlantic & Ontario Railroad Company, whose articles as organized go no farther west than Salisbury, near the west line of Fulton County. Hon. Calvert Comstock, of Rome, is president of the B. R. & O. R. R. Co., and I am indebted to him for much assistance in my examinations. Other organizations have been made, covering a line from Salisbury to Henderson Harbor, and from Boonville to Point Ontario, and surveys made of the routes. These surveys are generally somewhat fragmentary, though between Johnstown, Salisbury and Boonville, they appear to have been very judiciously made.

North of the Mohawk lies the elevated country which is known as the New York Wilderness. It is an uninhabited region of mountain and forest land. It has a drainage towards the east through the upper Hudson River and its tributary, the Sacondaga; a southern drainage into the Mohawk, through the Garoga and the two Canada Creeks, and a western drainage into Lake Ontario, through the Black River and its tributaries. These streams generally rise in lakes whose elevation is 1,600 feet and upwards above tide-water. An east and west railway must either be placed so far north as to pass through the wilderness above the watershed of the southern drainage, or it must cross the several tributaries of the Mohawk, and the divides between them.

Surveys have been made on different occasions for railroad lines passing north of these southerly water-courses, and practical routes can be found for them. Any such line, however, must ascend to the high elevation where the streams head, and be placed so far north as to be unavailable as a western connection for the Tunnel line, without great loss of distance. The most southerly line of this character would pass up the Sacondaga River, cross the summit near Piseco Lake, at an elevation of about 1,640 feet, and descend westward by the upper valley of West Canada Creek. The Sacondaga River flows south-easterly from Piseco Lake, and strikes the west line of Saratoga County at Northampton, approaching there within sixteen miles of the Mohawk, its elevation being 750 feet above tide-water; it then turns a sharp angle, flows north-easterly, and enters the Hudson at Luzerne, sixteen miles due north of Saratoga Springs. The drainage of the neighboring part of Saratoga County is parallel to the course of the Sacondaga, and a direct line from Mechanicville to Northampton would be compelled to pass over ridges 1,100 and 1,200 feet above tide-water.

A line passing south of the Wilderness, and across the tributaries of the Mohawk, has been found more practicable. Such a line must pass through Saratoga, Fulton, Herkimer, and part of Oneida Counties. The place of crossing the Hudson River, suggested for the Schenectady line, would be equally favorable for this.

Line through Saratoga County.

In Saratoga County, the difficulties in the way of construction would be small. From the Hudson River to Ballston, the same creek valley would be followed which is occupied by the Rensselaer & Saratoga railroad, five miles of the line being identical with the Schenectady route. At Ballston, fourteen miles from the Hudson, the elevation of the road would be 310 feet above tide-water. From Ballston west, the country is apparently flat, and of such character that a railroad could be constructed over it at small expense. It has, however, a steady ascending slope, and attains its full elevation about ten miles west of Ballston, and three miles east of the Fulton County line, being there about 800 feet above tide-water. A grade of fifty feet per mile, ascending westward for ten continuous miles, would be required, but the work would be light; little or no rock would be encountered, and there would be no expensive structures.

East Part of Fulton County.

Entering Fulton County, the general character of the surface does not change materially, but the slope of the country is southward towards the Mohawk, and the average elevation of an east and west line almost constant. It is, in brief, an inclined plateau, about twelve miles wide, sloping from the base of the high hills which are visible on the north, to the Mohawk, where it suddenly drops off into the narrow valley in which that river runs. It is more or less broken by undulations, but they are of such a character that they can be avoided by a well located line. These features continue about twelve miles. Fifteen miles from the east line of the county, the railroad would pass through Johnstown, the county-seat, and once the home of Sir William Johnson, of Mohawk Valley fame. At this point, the elevation of the railroad would be not far from 700 feet.

West Half of Fulton County.

Johnstown is situated on a small creek which rises a few miles farther north, and enters the Mohawk at Fonda. Ten and a half miles west of Johnstown is the Garoga Creek, and fifteen miles beyond, at the west line of the county, the East Canada Creek. Each of these streams has a very rapid fall, and the divides between them are continuations of the high country on the north, which drop off rapidly as they extend southward. By taking advantage of the rapid fall of the streams, each stream may be crossed at a higher level than the stream east of it, and by crossing the streams at an elevation above their beds, and selecting the lowest points in the ridges, the descent westward from each summit to the next stream can be reduced to a nominal amount, and the heavy construction work can be concentrated at the creek-crossings. This has been done very successfully by Mr. H. R. Snyder, of Johnstown, under whose directions the surveys for the Atlantic & Ontario railroad were made. His line ascends westward from Johnstown, crossing the Klipse Hills six miles beyond, with a cut not over twenty feet deep, and with no descending grade, crosses the Garoga Creek, 10.5 miles from Johnstown, 85 feet above the bed of the stream. In the next 7 miles, the line ascends 266 feet, to the summit between the Garoga and the East Canada Creek, and then descends 45 feet in 8 miles to the last named creek, which it crosses at an elevation of 50 feet above the bed of the stream. I am unable to give the exact elevation of these points above tide-water. It is virtually a line with a maximum gradient of 50 feet per mile, but with all the grades in favor of the traffic.

Excepting at the crossing of the creeks the work would be light; the whole line is through a well settled farming country, and little or no rock is seen in position excepting at the crossing of the Klipse Hills mentioned above. A survey made through the same country a few miles farther north, in the interest of the Boston, Rome & Oswego railroad, encountered work of an enormously heavy and expensive character.

Herkimer County.

The portion of Herkimer County which a railroad line in this direction must cross, lies between the two Canada creeks, and the divide between these two streams is much more formidable than the more easterly divides. The high country here extends across the Mohawk River, that river breaking through the ridge at the narrow and rocky gorge at Little Falls, the ridge elsewhere maintaining a general elevation of about 1,700 feet above tide-water, the lowest points being some 300 feet lower. The country on each side of the main ridge slopes rapidly from north to south, so that the abrupt and lofty hill which marks the divide between the Canada creeks near the Mohawk, becomes a modest ridge in a rolling country twenty miles further north. The West Canada Creek, after following a south-westerly course in this elevated rolling country, descends rapidly through a narrow limestone gorge at Trenton, falling in all 500 feet, from an elevation of 1,200 feet above the Falls, to one of 700 feet above tide-water, below the Falls. It then takes a south-easterly course and descends gradually to the Mohawk. The lowest summits in the divide are about 1,400 feet above tide. West of Herkimer County lies the level plateau through which the Erie Canal and New York Central railroad pass, the summit level of the canal being 427 feet above tide-water, and 182 feet above Lake Ontario. The summit, at an elevation of about 1,400 feet, is unavoidable, and from it a descent of nearly a thousand feet must be made by any railroad line to the West. If the West Canada Creek is crossed above Trenton Falls, the principal descent will be made after crossing the creek. If the crossing is below the Falls, the principal descent must be made on the broken face of the steep western slope of the divide.

The survey of the Boston, Rome & Oswego railroad, aiming at the most direct route to Rome, crossed the ridge through a summit in Fairfield township, at an elevation of 1,365 feet, 33 feet below the surface, and then, following the western face of the hill, descended with a long continuous grade of 40 feet per mile, the grade being in the opposite direction to the fall of the stream, crossed the West Canada Creek near Trenton, and the Utica & Black River railroad at Holland Patent, and thence went without difficulty to Rome. The rock which is so abundant at Little Falls is nowhere visible in the upper portion of the same ridge, but the soil is generally sand and the country occupied by dairy farms. The slope on which the line is located is broken and irregular, and though no rock is met with, the work of construction would be very expensive. The distance from the East Canada Creek to Rome, by this survey, is about 42 miles, making the entire distance from the Hudson River 110½ miles, or a mile and a half more from Albany than by the New York Central Railroad. A small difference, however, must be looked for on a corrected location. Any line crossing the West Canada Creek below the Falls must be in the immediate neighborhood of this one, though the details of this survey were very defective, and the cost of construction would be materially reduced by concentrating the descent in a heavy gradient where assisting power would be used in the operation of the road.

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The summit which would be crossed by a line crossing the West Canada Creek above the Falls lies at the heads of the Spruce and Black Creeks, tributaries of the two Canadas, in Norway township and on the border of the Wilderness. It is five miles north of the one selected for the Rome survey, and a few feet higher, but the difference is only nominal. Between the two there is but one place at which the ridge can be crossed, and that is so near the Fairfield summit as to give virtually the same results, except that it is about 50 feet higher. The summit in Norway township is considerably below the surrounding country, and has the general features of a summit in a valley, the streams not falling rapidly in either direction. The descent of Black Creek is gradual to the West Canada, and the water in Spruce Creek falls only about 100 feet in the first five miles from the summit; but it then falls suddenly in a succession of torrents several hundred feet. An ascent from the crossing of the East Canada Creek must, therefore, be made before following a natural watercourse. This can be done, requiring about six miles of careful location, on the greater part of which the work will be of heavy character, and at the sacrifice of some distance. Heavy work of the same character would be encountered in rising to the Fairfield summit. The West Canada Creek would be reached at the mouth of Black Creek, at a distance of about 24 miles from the East Canada and 4 miles above the head of the Falls.

From this point the line may be turned in several directions—either down the West Canada Creek, then by a route nearly the same as that of the Utica & Black River railroad to Holland Patent, and thence to Rome; or northward to Boonville and the Black River country; or on a course between the two, direct to Lake Ontario. On every line the descent westward must be made. The distance to Rome by this route would be a little more than by the Fairfield summit.

General Features.

The general features of the line north of the Mohawk may be briefly stated as follows:—

Distance about the same as by the Mohawk valley. A single summit to be crossed at an elevation about 1,400 above tide-water, or 950 feet above the country around Rome and the long summit level on the Erie Canal, and from which high elevation a descent of 1,300 feet must be made to the Hudson River. The principal portion of the ascent eastward can be concentrated into a single grade, where assisting power can be used; with this exception the ruling gradients of the line can be made 30 feet per mile ascending eastward, and 50 or 55 feet westward.

When the level plateau around Rome and the summit level of the canal is reached, the low grade lines to the west are no longer confined to a single valley, and a line equal in this feature to the New York Central Railroad can be constructed without difficulty. The Lake Ontario (Shore) railroad, recently sold out under foreclosure, has been bought in the interest of the Delaware, Lackawanna & Western, and the Rome, Watertown & Ogdensburg railroads, and now, in strong ownership, is being completed from Oswego to the Niagara River. There would be no difficulty in connecting with this road by such a route as to make a through line no longer than that of the New York Central railroad.

But as a through all-rail line to the West, it would be a long time before this route, climbing nearly 1,000 feet, merely to descend again into the same valley, would prove more than a weak competitor beside the New York Central railroad, with its complete western connections, its independent freight and passenger tracks, and its almost perfect location in a valley sloping gently in the direction of the traffic.

Lake Connection.

Regarded in a less ambitious light, this line is not without merit. It runs through a prosperous country, and by passing northward through the Norway summit it can be connected with the Utica & Black River railroad, near Remsen Station, where the elevation of that railroad is about 1,200 feet, and at a distance of about 93 miles from the Hudson River. This will open a line to the Black River country and the lower ports of Lake Ontario, 25 miles shorter than the route via Schenectady and Utica, and will bring that country 38 miles nearer Boston than it is now. The only port in this neighborhood with which Boston now has direct communication is

Ogdensburg on the St. Lawrence River, which is 405 miles from Boston by the Central Vermont railroad line. By this route and the Utica & Black River railroad, Clayton, 40 miles above Ogdensburg, will be brought within 365 miles of Boston, and Sackett's Harbor, which is reputed the best harbor on Lake Ontario, will be brought within 360 miles of Boston. It should be noted, however, that by restoring the abandoned railroad from Pierrepoint Manor, on the R. W. & O. railroad, Sackett's Harbor could be reached by way of Rome, with equal directness.

The completion of the Welland Canal enlargement, which is to give 12 feet of water throughout, will enable a larger class of lake vessels to enter Lake Ontario, and is expected to restore to the ports of that lake the importance which they formerly held. In connection with a line of steamers on the lakes a large business could be handled by this route, the land carriage being 130 miles less than from Buffalo. Of 13,000,000 bushels of grain transported eastward from Buffalo to New York by the Erie railway in the year ending September 30, 1874, 8,000,000 bushels were received from other railroads and 3,500,000 bushels came by lake. This indicates the value of a lake port, which is also a canal port, to a railroad line. A railroad connecting your road with the Black River country and the lower lake ports, judiciously managed and not too expensively constructed, might be made to prove a profitable investment and a valuable feeder, but the scheme is one which should not be taken up without the most careful consideration. I have seldom seen a country through which it would be easier to ruin a line by bad location, and a road built here on an independent basis, without the coöperation and good-will of other lines, would probably not only prove a failure in itself but might deprive the Tunnel route of the valuable connections from which it must for many years derive its heaviest traffic.

III. CONNECTING LINES OF WATER COMMUNICATION.

The principal route of water communication with which the Tunnel route will make connection is the Erie Canal and its tributary, the Oswego Canal.

Erie Canal.

The Erie Canal extends from Lake Erie at Buffalo to the Hudson River at Albany, its total length being 349¾ miles. It is remarkable for its long levels, the whole number of locks being only 71, of which 5, with a total lift of 43½ feet, are ascending eastward, and 66, with a total fall of 610 feet, are descending. Schenectady is 30 miles from Albany by the canal, and between the two points the canal has to overcome the falls of the Mohawk, which is accomplished by 22 locks, having a total fall of 130 feet.

Oswego Canal.

The Oswego Canal extends from Lake Ontario at Oswego to the Erie Canal at Syracuse. The length from the Lake to the junction is 38¼ miles, and the number of locks 18, with a total lift of 157 feet. The distance from the junction to Albany by the Erie Canal is 168 miles, and the number of locks 49, of which 3, with a total lift of 27 feet, are ascending, and 46, with a total fall of 427 feet, descending, making the total distance from Lake Ontario to the Hudson River 206 miles, total number of locks 67, of which 21, with a total lift of 184 feet, are ascending.

The following table shows the canal distances, the equivalent distances being computed by counting each lock as one mile:—

	Distance.	Ascending Locks.	Lift.	Descending Locks.	Fall.	Equivalent Distance.
Lake Erie to Albany,	350	5	43½	66	610	421
Lake Erie to Schenectady, . .	320	5	43½	44	480	369
Lake Ontario to Albany, . . .	206	21	184	46	427	273
Lake Ontario to Schenectady, .	176	21	184	24	297	221

There are also two proposed lines of water communication for vessels of a larger class than the boats which navigate the Erie Canal.

Oneida Lake Ship Canal.

The first of these is the Oneida Lake Ship Canal. This plan contemplates the improvement of the Oswego Canal from the Lake to Phœnix, 21 miles, the construction of a canal from thence to Oneida Lake, 13½ miles, the navigation of Oneida Lake, 23 miles, the construction of a canal from the east end of the Lake to the Erie Canal, 6 miles, and the enlargement of the Erie Canal to Troy, 128 miles. The work is one of considerable magnitude, the estimated cost being $25,000,000, of which nearly $20,000,000 is for the enlargement of the Erie Canal. This distance is given by Mr. McAlpine as 191½ miles, with 22 locks ascending, with a total lift of 182 feet; 53 locks descending, with a total fall of 427 feet. It is virtually the Oswego Canal route, improved for larger classes of vessels.

Caughnawaga Ship Canal.

The second proposed line is known as the Caughnawaga Canal route.

It contemplates following the St. Lawrence River, using the canals around the Rapids to Caughnawaga at the head of the Lachine Rapids above Montreal, the construction of a canal 34 miles long from there to the Richelieu River, navigation of that river and Lake Champlain to Whitehall, the enlargement of the Champlain Canal for a distance of 25 miles, and slack-water navigation in the Hudson River to Troy. There will be 35½ miles of canal navigation, with 22 locks, in the St. Lawrence Canals, and 34½ miles, with 3 locks, in the Caughnawaga Canal; there will be 25 miles of canal navigation, with 8 locks, in the Champlain Canal, and 40 miles of slack-water navigation, with 11 locks, in the Hudson River. This makes the actual amount of canal navigation between Lake Ontario and Lake Champlain 70 miles, equivalent to 93 miles of clear canal navigation without locks; and between Lake Champlain and Troy, 65 miles of actual canal and slack-water navigation, with 19 locks, equivalent to 84 miles of clear canal navigation. The canals west of Lake Champlain are generally short, and with intervals of deep-river navigation between them; in the lake and the Richelieu River there are 134 miles of continuous free navigation.

The Caughnawaga Canal lies entirely within Canadian territory, and, if built, it must be constructed by the Canadian authorities, or at least with the approval of that government. It has long been the opinion of Montreal merchants that the effect of its construction would be to divert the trade of the St. Lawrence River, southward, from a point just above the principal city and port of the Dominion; and this anticipated diversion has not been looked upon with favor by our provincial neighbors.

Should this line be opened, the Tunnel route could derive business from it, either at Albany, at Troy, or near Mechanicville, four or five locks being avoided at the latter point. It is not probable, however, that much traffic would be received from it at either of these places. Albany and Troy are both below the entire canal navigation, and but a few miles of slack-water navigation remain below Mechanicville. The distance from Boston to the nearest point at which the Tunnel route could receive freight, from vessels navigating the Caughnawaga Canal route, would be 187 miles, about two miles being required to descend from the bridge across the Hudson to slack-water in the river. The distance from Troy to New York is only 150 miles, of the cheapest kind of navigation, and the distance from New York to Boston, by the outside route, is about 350 miles; making the total distance from Troy to Boston, by water, 500 miles; which, on the basis of the freight arrangements in use between the Erie railway and the Metropolitan line of steamers, is equivalent to 165 miles of railroad carriage, making no allowance for cost of loading.

Freight intended for foreign shipment, after coming through the canals, would pass directly down the Hudson River to New York, and sea-going vessels passing through the canal with freight destined to Boston, would find it their cheapest course to sail down the Hudson, through the Sound, and deliver their freight without breach of bulk at a Boston wharf. It is doubtful, however, whether the commerce of this route would be conducted in sea-going vessels. The difference in first cost of barges and sea-going vessels, and in the number of hands required to man them, soon wipes out the cost of transhipment when barges can be safely navigated for any considerable distance. From the head of the St. Lawrence to Troy, the distance is 425 miles, and to New York city 575 miles, through which distances barges can be safely taken.

It is possible that large lake vessels could be economically taken through the short St. Lawrence Canals and the Caughnawaga Canal to Lake Champlain. But even if this should be done, nearly one-half of the canal navigation is south of this lake, and the ports of Lake Champlain are those from which New England could most economically receive cereals coming by this route. The distance from Boston to Whitehall, via Bellows Falls and Rutland, is 195 miles, only 4 miles more than to Troy, and only 9 miles more than to the nearest point at which slack-water on the Hudson could be reached by the Tunnel route. This 9 miles difference is obtained at the expense of the equivalent of 68 miles of canal navigation, and the 4 miles difference at the expense of the equivalent of 84 miles of canal navigation.

Comparison.

When the Caughnawaga Canal is built, the Vermont railroads may derive a good traffic from it; but the water route which the Tunnel line should look to, is that by way of Oswego. This line has been open for many years, with seven feet of water, and involves only 176 miles of canal navigation from Oswego to Schenectady, as against 135 miles of canal and slack-water navigation, and a total distance of 425 miles, from the entrance to the St. Lawrence to Troy. It is, moreover, a line which can be put in operation at once. The cost of transferring grain from large lake vessels to barges is very small, and barge lines are found the most economical mode of carriage in smooth water, where slow speed must be made. The St. Lawrence canals allow the vessels navigating Lake Ontario to pass down to the lower river; but this practice, once common, is now generally abandoned, and, for reasons of economy, grain is transferred to barges at Kingston, and in them taken down the river to Montreal. (See Report of Select Senate Committee, on Transportation Routes to the Seaboard, 43d Congress, 1st Session, page 175.) The New York canals are the property of the State, and free to all on the payment of the established tolls. A line of steamers could at any time be placed on the lakes, running in connection with a line of barges, between Oswego and Schenectady, where freight could be delivered to the trains of the Tunnel route. This line would be the one on which the Tunnel railroad would have the advantage over all the other lines into New England, both in grades and in distance; and if it were desired to open the transportation line with a large class of lake vessels before the completion of the Welland Canal enlargement, the transfer could for a time be made at Buffalo instead of at Oswego. The advantage of having equally accessible canal communication with these two lake ports is a very important one. The dimensions adopted for the locks of the improved Welland Canal are 270 feet long by 45 feet wide by 12 feet deep. On the lakes above, the size of vessels is limited only by the harbors, and the depth of water on the St. Clair flats. These generally allow the passage of vessels drawing fourteen feet, thus giving to Buffalo and the port of Lake Erie an advantage of two feet over Oswego and the ports of Lake Ontario, even after the completion of the Welland Canal enlargement.

Accompanying this report, will be found a map of the country between the Hoosac Tunnel and Lake Ontario, and two sheets of profiles.

On the map, the existing railroads are shown in black, the canals in green, and the various proposed railroad lines which are considered in this report, in red.

The first sheet of profiles gives the profile of the two lines from the Connecticut River to Schenectady, via the Boston & Albany railroad, and via the Tunnel and the proposed line near Mechanicville; also the three other lines from the Tunnel; viz., the Troy & Boston railroad, the Stevens route to Albany, and the Hancock and Stephentown route to the same point. These profiles of constructed roads have been taken from such records as were at my command, and are believed to be accurate in all governing points, though not to be trusted in too minute detail. The profiles of the unconstructed lines are partly from surveys furnished me, and partly from my own observations. They are believed to give correctly the governing points of the several lines, though a located road would conform to them only in general features. The unconstructed lines are everywhere given in red.

On the second sheet of profiles are given the connecting lines west of the Hudson River. The profile of the New York Central railroad is taken from the State Engineer's Report of 1856, and that of the Albany and Susquehanna railroad from the records in the office of that company. The western part of the proposed line north of the Mohawk is taken from the records of the Boston, Rome and Oswego survey, kindly furnished me by Mr. Comstock, and the eastern part from observations of the governing points partly collected by myself, and partly sent me by Mr. Snyder. All governing points have been practically verified by my own examinations. The profile of the Erie Canal is taken from the State Engineer's Report. This sheet, though showing no railroad lines beyond Rome and Binghamton, really gives the distinctive features of the several lines. From Rome to Buffalo, by the New York Central railroad, the distance is 188 miles, and from Binghamton to Buffalo, by the Erie railway, 208 miles. The grades on each line are excellent, the advantage being slightly with the Erie railway.

Respectfully submitted.

GEO. S. MORISON.

BOSTON, November 27, 1874.

DISTANCES FROM BOSTON,

Via Hoosac Tunnel and Erie Railway and Boston & Albany Railroad and New York Central Railroad.

DESTINATION.	Boston via Hoosac Tunnel and Erie Railway.	Percentage.	Boston via B. & A. R. R. and N. Y. C. R. R.	Percentage.
Buffalo, ...	543	109	498	100
Detroit, via G. W. R. R., .	793	108	734	100
Chicago, via M. C. R. R., .	1,077½	105	1,018	100
Cleveland, via L. S. & M. S. R. R., ...	747	109	681	100
Toledo, via L. S. & M. S. R. R.,	839	105	794	100
Chicago, via L. S. & M. S. R. R.,	1,082	104	1,037	100
Columbus, ...	876	106	819	100
Cincinnati, ...	983	106	925	100
Louisville, via Cincinnati, .	1,093	105	1,035	100
St. Louis, via Cincinnati, .	1,323	104	1,265	100
Indianapolis, . . .	1,020	105	963	100
Louisville, via Indianapolis, .	1,130	105	1,073	100
St. Louis, via Indianapolis, .	1,258	104	1,201	100
Chicago, via B. & O. Extension, ...	1,077	–	–	–
Toledo, via C. S. R., . .	820	106	773	100
Logansport, ...	986	105	939	100
Peoria, ...	1,158	104	1,111	100

DIRECT RAILWAY CONNECTION

BETWEEN

MASSACHUSETTS AND THE WEST.

ROUTES TO BE TRAVERSED, AND ADVANTAGES TO BE GAINED.

[*Extracts from a paper prepared for the use of the Boston, Hoosac Tunnel & Western Railroad Company, by direction of the Pennsylvania Railroad Company.*]

* * * * * * * * * *

In considering the subject of direct railroad communication between New England and the Mississippi Valley, via the Hoosac Tunnel and its approaches, various contingencies present themselves that cannot, and ought not, to be lightly passed over. Between the mountains extending along her western border and the region to be reached, lie the great states of New York and Pennsylvania. These states are now interwoven with railroad lines, some of which must be made available in any new route that may be opened. It is of the utmost importance, therefore, that due consideration be given to these existing routes,—to the questions of directness, of distance, of destination they present,—but above all, to the productions and industries along the lines available, so that the largest amount of benefit may be realized by our people, and the greatest stimulant given to their industries. Taking the route via the Hoosac Tunnel as the most direct and advantageous to connect Boston, the principal city and port of New England, with the important trade-centres of the West, it will be found that three important systems of railway are now in successful operation through the states of New York and Pennsylvania, with western terminal facilities complete, any one of which can be made available. These are the lines of the New York Central, those of the Erie, and those of the Pennsylvania Railroad Company. As to the route through Massachusetts, a glance at any railroad map will satisfy the observer that but one possesses all the advantages of directness, and available connections. This line traverses the entire length of the state, and intersects the railway system of New England,—the lines of which, as a rule, have direction north and south,—thus bringing every portion of the Eastern States in immediate connection with the line designated. The first point of direct contact with the through western lines is at Schenectady, in the State of New York, where the Central railroad is reached. The second connection is at Binghamton, where the Erie is intersected, and the third point is in the vicinity of Williamsport, in the state of Pennsylvania, where connection can be made with three of the through lines controlled by the Pennsylvania Railroad Company, viz., the Philadelphia & Erie, having outlets at Erie and Buffalo on Lake Erie, the "Low Grade," or Bennett's Branch railroad, connecting with the Allegheny Valley railroad, on the Allegheny River, and thence to Pittsburg and the north through the Oil Regions, and the Bald Eagle Valley railroad to Tyrone, through the Bituminous Coal-fields, and thence by the main line of Pennsylvania railroad, and its controlled connections, to all important points in the Mississippi Valley. For all practical purposes the gradients of these roads may be assumed as the same, because each one of them now carries, and probably always will carry, freight and passengers at as low rates per mile as its competitors.

* * * * * * * * * *

The distance from Boston to Schenectady, via the Hoosac Tunnel and its approaches, being taken as the basis for a calculation of mileage, by two of the routes to the cities of Pittsburg, Cleveland, Toledo, Chicago, Columbus, Cincinnati, Louisville, Indianapolis and St. Louis, and the distance by the Boston & Albany road being given to fairly represent the mileage of the third, the result is as follows :—

Table of Distances from Boston via Boston & Albany Railroad and New York Central Railway and Connecting Lines.

	Distance from Albany.	Distance from Boston.
Boston to Albany *via* Boston & Albany Railroad, 201 miles.		
Albany to Pittsburg *via* L. S. & M. S., B. C. & P.,* O. C. & A, R.* and A. V. R. Rs.,*	566	767
Albany to Cleveland *via* L. S. & M. S. R. R.,	481	682
Albany to Toledo *via* L. S. & M. S R. R,	594	795
Albany to Chicago *via* Gt. Western and Mich. Cent. R. Rs.,	818	1,019
Albany to Columbus *via* L. S. & M. S. and C. C. C. & I. R. Rs.,	619	820
Albany to Cincinnati *via* L. S. & M. S. and C. C. C. & I R. Rs. and L. C. & L. R. R.,	725	926
Albany to Louisville *via* L. S. & M. S. and C. C. C. & I. R. Rs.,	835	1,036
Albany to Indianapolis *via* L. S. & M. S. and C. C. C. & I R. Rs.,	763	964
Albany to St. Louis *via* L. S. & M. S. and C. C. C. & I., and I. & St. L. R. R.,*	1,025	1,226

* Owned or controlled by Penn. R. R. Co.

Table of Distances from Boston by Proposed Route and Erie Railway and Connecting Lines.

	Distance from Binghamton.	Distance from Boston.
Boston to Schenectady by proposed route, . . . 202 miles. Schenectady to Binghamton, *via* Alb. & Susq., . . . 130 " ——332 miles.		
Binghamton to Pittsburg *via* A. & G. W., O. C. & A. R. R.* and A. V. R. R.,*	434	766
Binghamton to Cleveland *via* L. S. & M S. Ry.,	388	720
Binghamton to Toledo *via* L. S. & M. S. Ry.,	501	833
Binghamton to Chicago *via* G. W. & M. C. R. Rs.,	743	1,075
Binghamton to Columbus *via* L. S. & M. S. and C. C. C. & I. R. Rs.,	526	858
Binghamton to Cincinnati *via* Atlantic and Gt. Western Ry,	647	979
Binghamton to Louisville *via* Atlantic & Gt. W. Ry. and L. C. & L. Ry.,	757	1,089
Binghamton to Indianapolis *via* L. S. & M. S. and C. C. C. & I. R. Rs.,	670	1,002
Binghamton to St. Louis *via* L. S. & M. S. and C. C. C. & I. and I. & St. L. Ry.,	932	1,264

* Owned or controlled by Penn. R. R. Co.

Table of Distances from Boston by Proposed New Route and Northern Central, Philada. & Erie, B. E. V. & Penn. R. R. and Connecting Lines.

	Distance from Pittsburg.	Distance from Boston.
Boston to Schenectady by proposed route, ... 202 miles.		
Schenectady to Binghamton *via* Alb. & Susq. R. R., . . . 130 "		
Binghamton to Ralston *via* proposed new route,* . . . . 75 "		
Ralston to Williamsport *via* N. C. Ry.,† . . . . 24 "		
Williamsport to Tyrone *via* P. &. E.† and B. E. V. R. Rs.,† . . . . 79 "		
Tyrone to Pittsburg *via* Penn. R. R., 131 "		
——641 miles.		
Pittsburg to Cleveland *via* C. & P. R. R.,† . .	150	791
Pittsburg to Toledo *via* P. Ft. W. & C.† and M. C. and L. M. R. Rs.,†	261	902
Pittsburg to Chicago *via* P. Ft. W. & C. R. R.,† .	469	1,110
Pittsburg to Columbus *via* P. C. & St. L Ry.,† .	193	834
Pittsburg to Cincinnati *via* P. C. & St. L Ry.,† .	313	954
Pittsburg to Louisville *via* P. C. & St. L. Ry.† and L. C. & L. R. R.,†	423	1,064
Pittsburg to Indianapolis *via* P. C. & St. L. Ry.,†	381	1,022
Pittsburg to St. Louis *via* P. C. & St. L. Ry.† and Vandalia Line,†	620	1,261

* Distance estimated. † Owned or controlled by Penn. R. R. Co.

Table of Distances from Boston by Proposed Route and Northern Central and Philada. & Erie R. Rs. and Connecting Lines.

	Distance from Williamsport.	Distance from Boston.
Boston to Schenectady by proposed route, ... 202 miles.		
Schenectady to Binghamton *via* Albany & Susq. R. R., ... 130 "		
Binghamton to Ralston *via* proposed new route,* . . . . 75 "		
Ralston to Williamsport *via* N. C. Ry.,† . . . . 24 "		
——431 miles.		
Williamsport to Erie *via* Phila. & Erie R. R.,† .	248	679
Williamsport to Buffalo *via* Phila. & Erie R. R.† and B., N. Y. & P. R. R.	219	650
Williamsport to Cleveland *via* Phila. & Erie R. R.† and L. S. & M. S. R. R., ...	343	774
Williamsport to Toledo *via* Phila. & Erie R. R.† and L. S. & M. S. R. R., ...	456	887

* Distance estimated. † Owned or controlled by Penn. R. R. Co.

Table of Distances, etc.—Continued.

	Distance from Williamsport.	Distance from Boston.
Williamsport to Chicago *via* Phila. & Erie R. R.* and L. S. & M S. R. R., ...	700	1,131
Williamsport to Columbus *via* Phila. & Erie R. R.* and L. S. & M. S. R. R. and C. C. C. & I. R. R.,	481	912
Williamsport to Cincinnati *via* Phila. & Erie R. R.* and L. S. & M. S. R. R. and C. C. C. & I. R. R.,	587	1,018
Williamsport to Louisville *via* Phila. & Erie R. R.* and L. S. & M. S. R. R. and L. C. & L. R. R., .	697	1,128
Williamsport to Indianapolis *via* Phila. & Erie R. R.* and L. S. & M. S. R. R., ...	625	1,056
Williamsport to St. Louis *via* Phila. & Erie R. R.* and L. S. & M. S. R. R. and Vandalia Line,* .	864	1,295

* Owned or controlled by Penn. R. R. Co.

Table of Distances from Boston by Proposed Route and Northern Central, Philada. & Erie and Low Grade Division of Allegheny Valley R. R. and Connecting Lines.

	Distance from Pittsburg.	Distance from Boston.
Boston to Schenectady by proposed route, ... 202 miles.		
Schenectady to Binghamton *via* Alb. & Susq. R. R, ... 130 "		
Binghamton to Ralston *via* proposed route,* . . . . . 75 "		
Ralston to Williamsport *via* N. C. Ry.,† . . . . 24 "		
——431 miles.		
Williamsport to Red Bank *via* L. G. Div. A. V. R. R.,† . . . . 190 miles.		
Red Bank to Pittsburg *via* A. V. R. R.,† . . . . 64 "		
——254 miles.		
Pittsburg to Cleveland *via* C. & P. R. R.,† . .	150	835
Pittsburg to Toledo *via* P. F. W. & C.† and M. C. & L. M. R. Rs.,†	261	946
Pittsburg to Chicago *via* P. F. W. & C. R. R.,† .	469	1,154
Pittsburg to Columbus *via* P. C. & St. L. Ry.,† .	193	878
Pittsburg to Cincinnati *via* P. C. & St. L. Ry.,† .	313	998
Pittsburg to Louisville *via* P. C. & St. L. Ry.† and L. C. & L. R. R., . . . , ...	423	1,108
Pittsburg to Indianapolis *via* P. C. & St. L. R. R.,†	381	1,066
Pittsburg to St. Louis *via* P. C. & St. L. Ry.† and Vandalia Line, ...	620	1,305

* Distance estimated.

† Owned or controlled by Penn. R. R. Co.

Comparative Table of Distances from Boston by Proposed Route.

DESTINATION.	Distance via N. Y. Cent. R. R. and Connecting Lines.*	Distance via Erie Railway and Connecting Lines.	Distance via Northern Central, P. & E., B. E. V. & P. R. Rs. and Connecting Lines.	Distance via Northern Central and Phila. & Erie R. Rs. and Connecting Lines.	Distance via Northern Central, P. & E., L. G. Div. A. V. R. R. and Connecting Lines.
	Miles.	Miles.	Miles.	Miles.	Miles.
Buffalo, . .	–	–	–	650	–
Erie, . .	–	–	–	679	–
Pittsburg, .	767	766	641	–	685
Cleveland, .	682	720	791	774	835
Toledo, . .	795	833	902	887	946
Chicago, . .	1,019	1,075	1,110	1,131	1,154
Columbus, .	820	858	834	912	878
Cincinnati, .	926	979	954	1,018	998
Louisville, .	1,036	1,089	1,064	1,128	1,108
Indianapolis, .	964	1,002	1,022	1,056	1,066
St. Louis, . .	1,226	1,264	1,261	1,295	1,305

* Distance from Boston, computed via Boston & Albany R. R. and from Albany.

* * * * * * *

The most essential requirement of Massachusetts is the securing of a certain, abundant and reasonably cheap supply of coal, because this is the only fuel known that exists in quantities sufficient to meet the present and future demands of her manufactories and people. The present supply of this fuel is mainly transported from the mines where produced, to the markets where consumed, by mixed routes of rail and water. Coming principally from the anthracite fields of Pennsylvania, it is first shipped by railways to the seaboard, then carried to ports on the New England coast, and lastly transported again by railroad to the interior manufacturing towns where consumed. This process of shipment is complicated and expensive, and no inconsiderable portion of its expense is owing to the high rates charged, perhaps necessarily, over her own roads, running from the interior to the coal ports. Compelled, as these roads are, to furnish special facilities for coal transportation, and having but limited amounts to carry for short distances, and that too at irregular intervals, they charge rates ranging from four cents per ton per mile, and upwards, making the increased cost to the consumer fully one dollar per ton for every twenty miles it is moved inland. Anthracite coal cannot, however, be relied upon as the fuel for manufactories. It is found only in a limited area of territory. It is mined at great expense. Its production and shipment are now controlled by a few large corporations, who fully understand its value, and will always prevent its sale at lower prices than they consider remunerative. In these prices are embraced interest charges on heavy capital invested in railroads, shipping, real estate, and mining operations. It is, besides, so peculiarly adapted, by its cleanliness and other properties, for household purposes, that the larger portion of the production will ultimately, and not remotely, thus be absorbed. Even in Pennsylvania, where alone anthracite coal is found in considerable quantity and of good quality, its use in mechanical industries is, to a considerable extent, being superseded by the cheaper and more abundant bituminous coals. The fuel which New England must rely upon in the future is, therefore, beyond all question, bituminous coal, and the mode and means by which that can best be secured are considerations of vital importance. A line uniting Massachusetts with the Pennsylvania railroad system will enter the great coal-field at its north-eastern limit, and will connect it, by the shortest and most direct route possible, with interior New England. This coal-field is called the Appalachian, and is of continental dimensions, being in its entirety eight hundred and seventy-five miles in length, extending through important parts of seven States, in a north-east and south-west direction, and is from thirty to eighty miles wide. The extreme north-eastern portions of this bed are in Pennsylvania, and embrace the anthracite basins, and the semi-bituminous basins, in Bradford, Lycoming, Tioga, Centre, Clearfield, Cambria, Bedford, Huntingdon, and Fulton counties, all of which are now extensively mined and transported to eastern and northern markets. In the language of a recent recognized authority on American coals, "these semi-bituminous regions produce what may emphatically be called the manufacturing and steam-making coal from which our country derives important elements of its greatness, as a producer from the raw material of whatever is used by man." Semi-bituminous coal, as found in the regions designated, contains only eleven or twelve, and always less than eighteen per cent. of volatile combustible matter, and not less than seventy per cent., and never more than eighty per cent., of carbon. It has a wider range in its use than any other kind of coal. For blacksmithing or iron-working purposes, it is admitted to be by far the best, being free from sulphur, and possessing qualities and properties peculiarly recommending it to that class of artisans. From the mines now worked in the counties of Pennsylvania already named, this coal is largely shipped to all eastern cities and towns, is carried into Canada, and throughout all the western states and territories, being everywhere the recognized fuel of the iron-worker. The largest demand, however, for this semi-bituminous coal, is for steam purposes, and for these its reputation is thoroughly established.

The total production of the mines in Tioga, Bradford, and Lycoming counties in 1871, was 1,299,544 tons, and fifty per cent. of this was used in locomotive engines alone. The qualities to which it is indebted for this very important market are, among others, that it burns so that steam may be quickly raised and maintained at a regular pressure. It also possesses high evaporative power, is capable of converting a large amount of water into steam with small consumption of coal, and is attended with little smoke, soot or cinder.

Ralston (which is the point of proposed junction of the new line of railroad with the Northern Central railway, controlled and operated by the Pennsylvania Railroad Company) is the location of the McIntyre coal mines, one of the most important in this semi-bituminous region.

The properties of the coal produced here are the same as already described, and the development of the district has been unusually rapid, showing the demand that exists for this excellent fuel. This region is also rich in iron ore and fire-clay, and in the near future will undoubtedly become a point of production of various articles of great general utility.

Another extremely rich and valuable coal deposit—in some respects the richest, probably, in all the bituminous region—is located on the line of the "Low Grade road," a short distance west of the Allegheny summit, and is now being extensively developed. Coal from this region will be advantageously shipped to all the markets of the East, and the construction of the proposed line of railroad would bring it, as well as many other exhaustless deposits, fairly within the reach of New England consumers.

Thus far no reference has been made to the immense area of bituminous coal west, and in the midst, of the Allegheny Mountains. This is the largest portion of the Pennsylvania coal region, and from it is shipped all the American gas-generating coal used in the eastern portions of the United States. Altogether the coal-field of Pennsylvania extends through or is found in thirty-nine of the sixty-six counties into which the state is divided, and of these, thirty-three contain, so far as geological research or practical mining has determined, bituminous and semi-bituminous coal; and six, anthracite. The system of railroads owned, operated and controlled by the Pennsylvania Railroad Company, penetrates twenty-seven of the bituminous and semi-bituminous counties, and four of the anthracite. No eastern outlet is furnished to the most productive of the bituminous coal regions, except by the lines of this company. In 1857 the bituminous coal carried on the Pennsylvania railroad was only 247,491 tons, and in 1873 the amount reached 3,229,214 tons, showing conclusively the rapid increase in the demand for this fuel.

* * * * * * *

Another important contingency to be considered, in connection with the proposed line of railway, is the cheap rate at which fuel for its locomotives can be obtained, thus materially lessening the cost of transportation. In 1871 the coal consumed by the Boston & Albany railroad cost the company $8.00 per ton, while that used by the Pennsylvania railroad cost but $1.50 per ton, showing a difference of $6.50 per ton. It is stated that the consumption of coal on the New York Central and Hudson River railroads amounts to 750 tons per annum for each locomotive run. Taking this as an average consumption for railroads doing a heavy traffic, it will be seen that the mere item of fuel becomes an important one in railway economy, and that the saving in this respect, by roads able to draw their supply direct from the mines, must result in a very perceptible cheapening of the cost of operating,—a result that will be all the more apparent as the limited supplies of wood, now to some extent used for fuel, are exhausted. The last official statement gives the number of locomotives owned by the railroad companies in Massachusetts at 908; and the fuel necessary to supply them for a year, would, at the price paid for coal by the Boston & Albany road, cost more than five millions of dollars.

Another important product of the region to be penetrated by the proposed railway line, is petroleum. The annual consumption of this in New England is difficult to arrive at, and is not essential to the proper consideration of the subject as it here presents itself.

That it is largely consumed for lubricating and illuminating purposes, can be inferred from the rapid decline in the production of whale oil, once such an important item in the business of the New England states, and from the fact that almost the first, if not the very first, successful efforts made to refine and prepare crude petroleum for various uses, were made at Boston. The shipments from that port to foreign markets during 1873 amounted to 2,458,356 gallons, and this notwithstanding the fact that all the advantages for such shipments were decidedly in favor of the ports south of Long Island Sound,—Boston having no direct connection with the oil-producing regions, and the trade she controlled being entirely attributable to the interest she held in the crude product at the wells, and the reputation gained by her manufacturers in utilizing it.

The largest shipments abroad of petroleum are to such ports as Havre, Marseilles, Antwerp, Bremen, Hamburg, Konigsburg, Gibraltar, and Malta, from whence it is carried into the manufacturing centres of France, Germany and Italy, to be used in various ways in the productive arts, thus demonstrating its value as an auxiliary to industries similar to those commanding a large part of the skill of the people of New England.

Petroleum production is so wonderful in its growth and its present proportions, as to legitimately command the careful attention of every business community. In 1859 the production of the Pennsylvania region did not probably exceed 3,000 barrels, while in 1872 it amounted to 6,539,000 barrels, being more than eight-ninths of the total production of the United States, and worth in its crude state about $25,000,000. In thirteen years it grew from nothing to rank as the third article in value exported from our shores. If the supply continues (as the best scientific and practical knowledge asserts it will), the proportion it bears to our foreign trade cannot be materially changed, because the uses to which it is applied abroad are constantly increasing.

The oil-producing territory of the Middle States is all, so far as now known, embraced in a belt of twenty miles in width, extending from Western New York, in a line parallel with the western slope of the Allegheny Mountains, into Tennessee. The present producing spots are in area the smallest specks upon this belt, and are scattered over it in an isolated and indiscriminate manner.

Of these spots the portions embraced in four counties in Pennsylvania produce, as already stated, eight-ninths of all the oil now brought into market, while those of West Virginia and Canada produce about a half of the remaining ninth.

With this oil territory, the system of railways controlled by the Pennsylvania Railroad Company, and with which the proposed line from Massachusetts will have a most favorable and advantageous connection, is closely, and almost exclusively, blended, controlling entirely its eastern transportation. Three trunk-lines owned by this company enter the petroleum region,—one on the northern extremity, one on the southern, and one in the centre; while an auxiliary line fol- ws the Allegheny River in its course through the well- nown belt, extending its branches along the tributary creeks hose names have become famous in connection with this onderful natural product. Connection with this system of ailroads will place Boston and other New England ports in direct communication with the only largely productive oil gion, giving them advantages nearly equal to New York, Philadelphia, and Baltimore for a legitimate share of this important trade, both domestic and foreign.

While New England is able now to draw her supply of lumber from the forests of Maine and Canada, and, by water mmunication, from Michigan and Wisconsin, yet a wise economy cannot be insensible to the advantages of a close d favorable connection with the great lumber markets on e Susquehanna River. A railroad is an avenue of local well as through trade, and one traversing a region producing a surplus of any staple will distribute that staple to all parts where a market can be found. Naturally, therefore, the proposed line would open up many new markets for the lumber manufactured at Williamsport, Lock Haven, and other points in Pennsylvania, and would thus benefit many communities along its course, as well as increase its own profitableness. The extent of this lumbering industry at the points designated is somewhat startling.

In the ten years terminating with 1872 there was handled by the Susquehanna Boom Company, at Williamsport, 8,312,013 saw-logs, representing 1,642,801,101 feet, board-meaure. In the five years terminating with 1872 the amount handled by the West Branch Boom Company, at Lock Haven, amounted to 135,883,446 feet.

On the first of January, 1874, the amount of lumber in the hands of manufacturers and dealers at these two points, amounted to 172,869,351 feet of white pine; 23,333,096 feet hemlock, 63,436,100 laths, and 5,053,655 pickets.

Such aggregates as these certainly indicate a business of sufficient importance to be taken into consideration by any prudent community looking to the developement of their trade. As it is frequently asserted that the lumber supply of Pennsylvania is rapidly approaching exhaustion, it may be well to give a few statistics bearing upon this subject. In June of the present year the "National Association of Lumbermen" convened in Williamsport, and among the reports made to its president was one showing the "quantity of standing white pine, hemlock, and hard wood timber, east and west of the Allegheny Mountains, in the state of Pennsylvania."

The totals of this estimate, which was carefully prepared by experienced lumbermen, were as follows:—

Standing white pine, ...	3,600,000,000	feet.
Standing hemlock, ...	7,000,000,000	"
Standing hard-wood, fit for saw-logs, .	4,000,000,000	"
Aggregate of all kinds, . . .	14,600,000,000	feet.

The distance by the proposed line of road from a central point in the bituminous coal-fields of Pennsylvania, to a central point of distribution in Massachusetts, would be about 450 miles. Allowing the costs of transportation of coal over this route to be the same as that now charged over the Pennsylvania railroad and its branches, viz., $.00\frac{933}{1000}$ cent per ton per mile, this would make the freight on coal $\$4\frac{20}{100}$ per ton; add to this the cost of bituminous coal delivered on cars at the mines, say $1.20 per ton—a price at which contracts for any amount can now be made—and the total cost of coal delivered in Central Massachusetts, would be $5.40 per ton.

The fair presumption is, that this price would be lowered rather than increased when the line was in practical operation, because coal can be carried for long distances at a less cost per ton per mile than for short, and the sources from which a supply for the New England market could be secured, such, for instance, as the Ralston and other well-known deposits, would be considerably nearer than the point from which the distance above given is calculated.

In presenting the summary of facts herein contained, the design has been to give only such as legitimately bore upon the interests of the New England States, and to avoid everything that savored of unfairness. If preponderance has been given to the consideration of the subject of coal supply, the reasons are, that nothing is deemed of more importance to the future of our manufacturing industries, and that the region designated holds the only fuel that can be made available for New England purposes. While, therefore, the distances from Boston to the important centres of the West may not be less by way of the Pennsylvania railroad system than by other available routes, the advantages to be gained by this connection are numerous.

All important terminal points on the Great Lakes, the Ohio and Mississippi rivers, and in the South, can be reached over direct and unbroken lines, and travel and traffic thus be more generally and advantageously accommodated than by any other route. But above all, in importance, stands the fact that this route alone can place the New England states in complete contact with a region which not only monopolizes the most essential requisite to their future prosperity, but holds in its bosom other treasures of vast importance to their industry, progress and comfort.

[C.]

REPORT OF THOMAS DOANE,

Consulting Engineer,

ON THE WORK DONE IN THE PROCESS OF RECONSTRUCTING THE TROY & GREENFIELD RAILROAD.

[Referred to in Report, Page 4.]

To the Corporators of the Boston, Hoosac Tunnel and Western Railroad Company, Hon. W. B. Washburn, *President.*

I beg leave to present the following report of what has been done under your authority in the matter of reconstructing the Troy & Greenfield railroad.

Wm. P. Granger, who is acting as chief and constructing engineer, has had charge of the active work of rebuilding, while Edwin Stratton has made the various surveys east of Bardwell's Ferry, which substantially cover the whole ground. Both of these gentlemen have reported to me informally.

The results of Mr. Stratton's work have been presented to you in detail in my report of December 19, 1874.

As therein intimated, nothing is being done in way of rebuilding this road between Greenfield and Bardwell's Ferry, except to make up results of surveys, and it awaits legislative decision as to the route to be adopted.

If the present line be substantially adhered to, it will cost to rebuild this piece of road,—

For graduation, masonry, and bridging, about	$365,910 00
For eight miles steel track, ...	96,000 00
Total, ...	$461,910 00

An important item in the above cost is for a new bridge over Green River. The present bridge is not secure, and its location will have to be changed if it is decided to reduce the very sharp curvature at that point.

The plan adopted for rebuilding this road is as follows:—

The nature of the Deerfield River valley, which is very narrow and crooked, determines the character of so much of the road as lies in it. The country cannot be forced to any great extent without excessive cost.

In House Document No. 9, 1874, Mr. Philbrick gives the following table of curvature, which covers the present line from Greenfield to the Tunnel:—

DEGREES.	Radius in Feet.	Total Curvature.	Length of Curves in Feet.
1°, ...	5,730	8° 21′	1,060
2°, ...	2,865	198° 28′	10,888
3°, ...	1,910	430° 56′	14,267
4°, ...	1,432	735° 45′	18,808
5°, ...	1,146	1,000° 49′	19,762
6°, ...	955	1,125° 54′	19,044
7° to 11°, ...	819 to 552	486° 49′	6,071
		3,987° 02′	89,899

From this table it will be seen that the larger amounts in degrees of curvature are of 5° curves and 6° curves, while the amount above 6° is comparatively small, though covering more than a mile. It was therefore decided to reduce all the curvature to 6° curves, or less. This will retain the road in its present location very largely. Where wholly new work is required in making changes, the curves are reduced to 5°. One costly change is now being made near Bardwell's Station, which necessitates a rock and earth cut over 60 feet deep for a distance of 800 feet, and a new bridge across the Deerfield River.

Another change must be made through the village just west of the Shelburne Falls Station, which will result in considerable outlay for land damages. Still another important change is being made in alignment at a point about one (1) mile above Zoar depot.

Other than as above the alignment is not much changed, except to true up the curves and get as much straight line as possible between those turning in reverse directions. All curves on important bridges are also being thrown out.

The masonry is being improved in quality and built in all cases sufficient for another track.

That part of the road between Bardwell's Ferry and Shelburne Falls, $5\frac{24}{100}$ miles, is under contract to B. N. Farren, to be completed for a single track by July 1, 1875. That part between Shelburne Falls and the Tunnel is under contract to N. C. Munson, to be completed at same time and in same manner as that part let to Mr. Farren.

It is difficult to estimate closely the cost incurred by these contracts, but

For graduation, masonry, and bridging it will probably amount to about	$683,500 00
For 21 miles steel track, at $12,000, ...	252,000 00
Total, ...	$935,500 00

The wooden Howe-truss double-track bridge over the Deerfield River, near the easterly end of the Tunnel, which was strained by overloading with stone and want of care, and which perhaps was rather light at first, has had a third truss added in the middle, and is otherwise undergoing thorough repair.

No estimate is made for work yet to be done in the Tunnel. It is open through, but the track is not yet laid. It is built for a double track. The road from the west portal of the Tunnel to North Adams depot is built for a double track as to graduation, masonry, and bridging, and is two miles long.

That portion of the Troy & Greenfield railroad which lies west of North Adams and extends to the Vermont State line, is 6.84 miles long, built for a single track. The maximum grade rising east is now about seventy-nine feet per mile, and rising west, forty-six feet; both for short distances near the Little Tunnel. Other than here, the maximum grade east is forty-two feet, and west twenty feet. In rebuilding, the maximum east can easily be reduced to 31.68 feet per mile, and all the grades rising west to levels.

The adopted location of the road from the great Tunnel to North Adams, involves using a 6° curve in getting into and through the Little Tunnel. Aside from this, the sharpest curve west of North Adams is of 3½°.

THE LITTLE TUNNEL AT NORTH ADAMS.

This was not built for the present location, and must be very much enlarged and changed. The minimum width is twelve and one-half, and height fifteen feet.

A level grade from the North Adams depot through the Tunnel will do away with both of the heavy grades entering it, and the cut of eight feet thus made necessary in the bottom of the Tunnel will give it the necessary height.

Building the Tunnel to the 6° curve mentioned above, will make the easterly mouth of it about fifty feet wide, which is rather a dangerous width for a tunnel, and, unless the rock is very sound, may lead to an open cut. Possibly another and separate tunnel may be required. To build this portion of the Troy & Greenfield between North Adams and the Massachusetts and Vermont State line, will require,—

For graduation, masonry, and bridges, about . . .	$120,578 00
For enlargement of Little Tunnel, ...	52,300 00
For 6.84 miles steel track, ...	82,080 00
	$254,958 00

SOUTHERN VERMONT RAILROAD.

This is a single-track railroad lying in the State of Vermont. It is 6.17 miles long. It is not in good condition. Wooden culverts and cattle-guards should give place to stone.

The maximum grade rising east is now about sixty-two feet per mile, for a short distance, and rising west, about fifty-three feet per mile. The sharpest curve is of 3°. This road is not in condition for a large business, and will have to be rebuilt or repaired at the expense of the Troy & Boston Co. If repaired on the scale proposed for the Troy & Greenfield railroad, the maximum grade east can easily be reduced to 31.68 feet per mile, and all the grades rising west to level planes.

The cost of putting this road into condition for a single track will be,—

For graduation, masonry and bridging, about	$179,260 00
For steel track, if used, ...	74,040 00
Total, ... , . . .	$253,300 00

In all the preceding estimates the amounts for single track include cost of first quality masonry for two tracks, a first-class track of sixty-pound steel rail, and iron bridges for single track; iron being preferred, not alone on the ground of economy, but because indestructible by fire.

The following is a table showing characteristics and approximate cost of single and double line over the various portions, from Greenfield to Vermont and New York State line, supposing the road to be retained in its present location between Greenfield and Bardwell's :—

NAME OF SECTION.	Length in miles.	Max. grade per mile going West.	Rise in feet going West.	Max. grade per mile going East.	Rise in feet going East.	Max. curve in degrees.	Per cent. of Straight Line.	Degrees of Curvature per mile.	Cost of Single Track, double for masonry.	Additional Cost of Second Track.
Cheapside to West Deerfield, ...	4.51	52.8	121	0	0	6	49	116	$214,500	$138,253
West Deerfield to Bardwell's, ...	3.47	32	6	23	60	6	32	127	247,410	58,480
Bardwell's to Shelburne Falls, ...	5.24	50	221±	0	0	6	44±	156±	429,750	200,000
Shelburne Falls to Charlemont, ...	7.86	50	126±	30.6	25±	6	60±	113±	227,350	278,000
Charlemont to Tunnel, ...	9.07	50	226±	0	0	6	43±	146±	278,400	250,000
Hoosac Tunnel, ...	4.75	26.4	59.93	26.4	61	0	100	0	64,125	64,125
Tunnel to North Adams, ...	2.00	0	0	41.2	71.2	4	58	68	24,000	24,000
North Adams to Massachusetts and Vermont Line, .	6.84	0	0	32	121	6	62	46	254,958	177,580
Mass. and Vt. Line to Vt. and New York Line, .	6.17	0	0	32	85	3	66	52	253,300	166,550
	49.91	52.8	760	41.2	423	6	57	92	$1,993,793	$1,356,988

Leaving out the last item, viz., the Southern Vermont Railroad, and we have footings as follows:—

Troy and Greenfield Railroad, ...	43.74	52.8	760	41.2	338	6	60	97	$1,740,493	$1,190,438

I would here suggest that a contract be made soon for rebuilding that portion of the road west of North Adams, including the Little Tunnel. This latter will occupy considerable time, and should be out of the way before business begins to accumulate. Nearly all of the road west of the Tunnel can as well be graded up this winter as afterward, by putting in a steam-shovel and gravel-trains. The masonry should be left till spring, as well as the embankments over or adjacent to it.

Respectfully,

THOMAS DOANE,
Consulting Engineer.

CHARLESTOWN, MASS., Dec. 23, 1874.

[D.]

REPORT OF MR. DOANE,

Consulting Engineer,

ON THE LOCATION OF ROUTE BETWEEN BARDWELL'S FERRY AND GREENFIELD.

[Referred to in the Report, Page 7.]

To the Corporators of the Boston, Hoosac Tunnel, & Western Railroad,
Hon. W. B. Washburn, *President.*

I beg leave to submit the following report upon routes through Greenfield and Deerfield. It is believed that the seven different ones shown in the tables represent all the practical combinations.

They are each made to cover the whole distance between the extreme points of divergence, namely, Grout's Corner on the Vermont & Massachusetts railroad, and Bardwell's Station on the Troy & Greenfield railroad, so that their lengths, costs, and various characteristics can the more easily be compared.

The surveys were largely made by William P. Granger and Edwin Stratton.

ROUTE NO. I.

This route begins at Grout's Corner, and runs by a new line, to be built through Turner's Falls and North Greenfield, to West Deerfield, and thence by the present line to Bardwell's. This route involves very heavy work between Grout's and Greenfield. It accommodates Turner's Falls and Greenfield, but leaves Montague out of the line. The route will cross overhead of Conn. River R. R.

It is indicated on the plan by letters A, B, C, D, E, F.

NAME OF SECTION.	Length in miles.	Max. grade per mile going West.	Rise in feet going West.	Max. grade per mile going East.	Rise in feet going East.	Max. curve in degrees.	Per cent. of Straight Line.	Degrees of Curvature per Mile.	Cost of Single Track, double for masonry.	Additional Cost of Second Track.
Grout's Corner to Conn. River R. R. at North Greenfield via Turner's Falls, ...	7.46	40	91	40	151	7	52	74	$795,700	$272,300
Conn. River R. R. at North Greenfield to Green River, ...	.51	0	0	40	21	0	100	0	56,000	11,060
Green River to West Deerfield, ...	4.13	32	86	0	0	5¾	75	49	426,100	107,130
West Deerfield to Bardwell's, via present line, .	3.47	32	6	23	60	6	32	127	247,410	58,480
	15.57	40	183	40	232	7	43	77	$1,525,210	$448,970

ROUTE NO. II.

This begins at Grout's and runs by the present line to Cheapside, and thence to the present Greenfield Depot; thence by a new line crossing Green River by the Brick Yard to West Deerfield, and thence over the present line to Bardwell's.

This is not a very heavy line to build, presents favorable grades and curves, and accommodates Montague and Greenfield, but leaves Turner's Falls out of the line.

It is indicated on the plan by letters A, G, H, J, I, D, E, F.

NAME OF SECTION.	Length in miles.	Max. grade per mile going West.	Rise in feet going West.	Max. grade per mile going East.	Rise in feet going East.	Max. curve in degrees.	Per cent. of Straight Line.	Degrees of Curvature per mile.	Cost of Single Track, double for masonry.	Additional Cost of Second Track.
Grout's to Cheapside Junction via present line Vt. and Mass. R. R.,	7.42	44	72	44	169	5	47	80	0	$242,100
Cheapside Junction to Greenfield Depot,	.75	17	5	0	0	½	*	*	0	20,000
Greenfield Depot to Green River,	.57	32	9	0	0	5¾	43	137	$47,400	14,688
Green River to West Deerfield,	4.13	32	86	0	0	5¾	72	49	426,100	107,130
West Deerfield to Bardwell's,	3.47	32	6	23	60	6	32	127	247,410	58,480
	16.34	44	178	44	229	6	50	129	$720,910	$442,398

* Slight.

ROUTE NO. III.

This begins at Grout's, and runs substantially on the present line by Montague, Cheapside and West Deerfield, to Bardwell's. The worst physical feature in it is its heavy grade. It crosses the Connecticut River Road at grade.

It accommodates Montague, but does not accommodate Turner's Falls or Greenfield.

It is indicated on the plan by letters A, G, H, J, E, F.

NAME OF SECTION.	Length in miles.	Max. grade per mile going West.	Rise in feet going West.	Max. grade per mile going East.	Rise in feet going East.	Max. curve in degrees.	Per cent. of Straight Line.	Degrees of Curvature per mile.	Cost of Single Track, double for masonry.	Additional Cost of Second Track.
Grout's to Cheapside Junction, via present line Vt. and Mass. R. R., ...	7.42	44.0	72	44	169	5	47	80	0	$242,100
Cheapside Junction to West Deerfield, via present line Troy and Greenfield R. R., ...	4.51	52.8	121	0	0	6	49	116	$214,500	138,253
West Deerfield to Bardwell's, via present line Troy and Greenfield R. R., ...	3.47	32.0	6	23	60	6	32	127	247,410	58,480
	15.40	52.8	199	44	229	6	44	101	$461,910	$438,833

ROUTE NO. IV.

This begins at Grout's, and runs over the present line to a point a little west of the Connecticut River Bridge, and thence by a new line passing *under* the Connecticut River R. R., a little south of its Deerfield River Bridge; thence through Deerfield Village and across the Deerfield River to a junction with present road west of West Deerfield Station, and thence to Bardwell's, over present road. This is the Laurie route substantially. It involves large expense for bridging Deerfield River, and is much exposed to Deerfield River freshets. It accommodates Montague and Deerfield, and leaves out of the line Turner's Falls and Greenfield.

It is indicated on the plan by letters A, G, H, K, M, L, O, F.

NAME OF SECTION.	Length in miles.	Max. grade per mile going West.	Rise in feet going West.	Max. grade per mile going East.	Rise in feet going East.	Max. curve in degrees.	Per cent. of Straight Line.	Degrees of Curvature per mile.	Cost of Single Track, double for masonry.	Additional Cost of Second Track.
Grout's to junction West of Conn. River via present line Vt. and Mass., ...	6.09	44	45	44	161	5	47	80	0	$188,100
Junction West of Conn. River to crossing Conn. River R. R. near Deerfield River Bridge, . .	.99	0	0	11	11	5¾	18	238	$76,600	30,000
Crossing Conn. River R. R. near Deerfield River Bridge to junction with old line, . . .	5.92	42	110	11	20	6	64	74	518,000	280,900
Junction with old line to Bardwell's, . . .	1.56	0	0	18	14	5¾	56	114	70,609	20,592
	14.56	44	155	44	206	6	53	92	$665,209	$519,592

ROUTE NO. V.

This begins at Grout's and runs over the present line to a point a little west of the Connecticut River Bridge, and thence by a new line, passing *under* the Connecticut River Railroad, a little south of its Deerfield River Bridge; thence through Deerfield Village and by a route south of the Deerfield River and meadows to Stillwater; thence up the Deerfield Valley on its south side, about one (1) mile above the Suspension Bridge, where it crosses the Deerfield and runs up on the north side to Bardwell's. This is the most favorable line for grade and curvature, and avoids by an increase of length the exposure and cost incident to crossing the Deerfield River by Mr. Laurie's line. It accommodates Montague and Deerfield, and perhaps Conway, but avoids Turner's Falls and Greenfield.

It is indicated on the plan by letters A, G, H, K, M, N, F.

NAME OF SECTION.	Length in miles.	Max. grade per mile going West.	Rise in feet going West.	Max. grade per mile going East.	Rise in feet going East.	Max. curve in degrees.	Per cent. of Straight Line.	Degrees of Curvature per mile.	Cost of Single Track, double for masonry.	Additional Cost of Second Track.
Grout's to Junction West Conn. River, via present line, ...	6.09	44	45	44	161	5	47	80	0	$188,100
Junction West Conn. River to Crossing Conn. Riv. R. R., near Deerfield River Bridge, . . .	0.99	0	0	11	11	5¾	18	238	$76,600	30,000
Crossing Conn. River R. R., near Deerfield River Bridge, via Stillwater to Bardwell's, . . .	8.00	22	95	11	20	5	65	77	437,413	233,860
	15.08	44	140	44	192	5¾	55	88	$514,013	$451,960

ROUTE NO. VI.

This begins at Grout's and runs by a new line to be built through Turner's Falls to North Greenfield; thence by the side of the Connecticut River R. R. to its present Greenfield Depot, there crossing that road; thence by its westerly side across the Deerfield River by a new bridge; thence through Deerfield Village and across the Deerfield River again to a junction with present road west of West Deerfield Station, and thence to Bardwell's over present road. This route involves heavy expense at Turner's Falls and on the Deerfield meadows, besides exposure to Deerfield River. This route accommodates Turner's Falls, Greenfield, and Deerfield, but leaves out Montague.

It is indicated on the plan by letters A, B, C, I, J, K, M, L, O, F.

NAME OF SECTION.	Length in miles.	Maximum grade per mile going West.	Rise in feet going West.	Maximum grade per mile going East.	Rise in feet going East.	Maximum curve in degrees.	Per cent. of Straight Line.	Degrees of Curvature per mile.	Cost of Single Track, double for masonry.	Additional Cost of Second Track.
Grout's to Conn. River R. R. at North Greenfield via Turner's Falls, ...	7.66	40	91	40	151	7	52	74	$795,700	$272,300
Conn. River R. R. at North Greenfield to Greenfield Depot, ...	.50	0	0	32	17	4	39	129	0	12,000
Greenfield Depot to crossing Conn. River R. R. near Deerfield River Bridge, ...	1.31	0	0	26	34				174,500	70,000
Crossing Conn. River R. R. near Deerfield River Bridge to junction with old line, . . .	5.92	42	110	11	20	6	64	74	518,000	280,900
Junction with old line to Bardwell's, . . .	1.56	0	0	18	14	$5\frac{3}{4}$	56	114	70,609	20,592
	16.75	42	201	40	236	7	56	78	$1,558,809	$655,792

ROUTE No. VII.

This begins at Grout's, and runs by a new line to be built through Turner's Falls to North Greenfield; thence by the side of the Connecticut River R. R. to its present Greenfield Depot, there crossing that road; thence by its westerly side, across the Deerfield River by a new bridge; thence through Deerfield Village and by a route south of the Deerfield River and meadows to Stillwater; thence up the Deerfield valley on its south side, about one (1) mile above the Suspension Bridge, where it crosses the Deerfield and runs up on the north side to Bardwell's. This route incurs heavy expense at Turner's Falls, but accommodates Turner's Falls, Greenfield, Deerfield, and perhaps Conway, leaving out Montague.

It is indicated on the plan by the letters A, B, C, I, J, K, M, N, F.

NAME OF SECTION.	Length in miles.	Maximum grade per mile going West.	Rise in feet going West.	Maximum grade per mile going East.	Rise in feet going East.	Maximum curve in degrees.	Per cent. of Straight Line.	Degrees of Curvature per mile.	Cost of Single Track, double for masonry.	Additional Cost of Second Track.
Grout's to Conn. River R. R. at North Greenfield, via Turner's Falls, ...	7.46	40	91	40	151	7	52	74	$795,700	$272,300
Conn. River R. R. at North Greenfield to Greenfield Depot, ...	0.50	0	0	32	17	4	39	129	0	12,000
Greenfield Depot to Crossing Conn. River R. R. near Deerfield River, ...	1.31	0	0	26	34				174,500	70,000
Crossing Conn. River R. R. near Deerfield River, via Stillwater to Bardwell's, ...	8.00	22	95	11	20	5	65	77	437,413	233,860
	17.27	40	186	40	222	7	56	75	$1,407,613	$588,160

The following is a Summary of the Seven (7) Routes before given more in detail, all reaching from Grout's Corner to Bardwell's Station.

NAME OF ROUTE.	No. of Route.	Length in miles.	Maximum grade per mile going West.	Rise in feet going West.	Maximum grade per mile going East.	Rise in feet going East.	Maximum curve in degrees.	Per cent. of Straight Line.	Degrees of Curvature per mile.	Cost of Single Track, double for masonry.	Additional Cost of Second Track.
Via Turner's Falls, North Greenfield and West Deerfield, ...	I.	15.57	40	183	40	232	7	43	77	$1,525,210	$448,970
Via Cheapside, Greenfield Depot and West Deerfield, ...	II.	16.34	44	178	44	229	6	50	129	720,910	442,398
Via present route, ...	III.	15.40	52.8	199	44	229	6	44	101	461,910	438,833
Via Montague and Deerfield, . . .	IV.	14.56	44	155	44	206	6	53	92	665,209	519,592
Via Montague, Deerfield and Stillwater, .	V.	15.08	44	144	40	192	5¾	55	88	514,013	451,960
Via Turner's Falls, Greenfield Depot and Deerfield, ...	VI.	16.75	42	201	46	236	7	56	78	1,558,809	655,792
Via Turner's Falls, Greenfield Depot, Deerfield and Stillwater, ...	VII.	17.27	40	186	40	222	7	56	75	1,407,613	588,160

The determination of the particular route to be adopted will probably be based both upon its engineering characteristics and the accommodation it will afford to local interests. Some concessions to locality seem to be demanded, the more especially as local business will be much more remunerative to the line than through business.

Respectfully,

THOMAS DOANE,
Consulting Engineer, etc.

CHARLESTOWN, MASS., December 19, 1874.

[E.]

OPINION OF THE ATTORNEY-GENERAL

On the Construction of Chapters 365, 402 and 403 of the Acts of 1874, in relation to the Duties and Authority of the Governor and Council and the Boston, Hoosac Tunnel & Western Railroad Company, over the Work to be done in the Completion of the Hoosac Tunnel.

[Referred to in the Report, Page 7.]

COMMONWEALTH OF MASSACHUSETTS.

Attorney-General's Office,
Boston, 7 Court Square, July 7, 1874.

To His Honor the Lieutenant-Governor:

Dear Sir:—In accordance with your request of this morning, I have examined chapters 365, 402 and 403 of the acts of 1874, and am of opinion that chapter 403, the act providing for the management of the Hoosac Tunnel, etc., does not relieve the governor and council from the duties imposed upon them by chapter 365, the act authorizing the governor and council to expend a sum of money not exceeding $300,000, etc.

The later act (chapter 403) does not in terms, or by any reference, or by any general clause repealing other acts inconsistent with it, purport to repeal the earlier. Both acts were passed by the same legislature, with a difference of only five days in the dates of their respective approvals. The two acts are not upon the same subject-matter, the later being of a much more comprehensive and general character than the earlier. Certain provisions in the earlier, namely, those contained in chapter 3, are not covered by any of the provisions of the later act. If the later act was construed to repeal the earlier, it would substitute another body than the governor and council for the acceptance of the Shanly contract. This could not be done without the consent of the Shanlys, as it would impair the obligation of a contract already made. If the legislature had intended to make any change in this respect, provision would have been made for the consent of the Shanlys. These considerations and others, which the shortness of the time at my command compel me to omit, lead me to the opinion that if the legislature had intended to repeal chapter 365 by chapter 403, passed almost contemporaneously with it, they would not have left such purpose to mere inference and implication.

In regard to chapter 402, the Act providing for the completion of the Troy & Greenfield railroad, I am of opinion that the last clause in section four of this act, relative to the expenditure of the appropriation, is repealed by chapter 403. The language of this clause is, that the expenditure shall be intrusted to the governor and council unless the legislature, by an act passed at the present session, makes some other provision with reference thereto. This clearly implies a possible repeal of that clause by the same legislature, and they did at once pass an act, namely, chapter 403, which, in section 6, expressly referred to this act, and which provided another body than the governor and council to which the expenditure of the money was intrusted. In regard to the extent of the power conferred upon the company created by chapter 403 over the money appropriated by chapter 402, I do not understand any question has yet arisen, and, perhaps, it would be premature to express in advance any opinion.

As the legislature have not provided that said company should give any bonds or security for the large sum of money appropriated by chapter 402, the more obvious conclusion is that all that was intended by the broad language used was, that the money should remain in the state treasury, subject to the order of the company, whenever it appeared by the proper vouchers that expenditures authorized by the act had been incurred.

This view of the matter is strengthened by the provision of chapter 360, section 2, of the Acts of 1874, "that no greater sum from any appropriation for any institution, board or department of the State, shall be drawn from the treasury at any one time than is necessary to meet expenditures then incurred."

Very respectfully yours,

WILLIAM G. COLBURN,
Assistant Attorney-General.

COMMONWEALTH OF MASSACHUSETTS.

Attorney-General's Office,
Boston, 7 Court Square, July 20, 1874.

To His Honor the Lieutenant-Governor:

Sir:—Since our interview, on the 13th inst., I have carefully examined the opinion given by the Assistant Attorney-General under date of the 7th inst., and fully concur therein. The principal feature of chapter 365, Acts of 1874, is the power given by section 3 to the governor and council to make a settlement, under the Shanly contract, the grant of three hundred thousand dollars being made obviously for that purpose.

Chapter 402 is "An Act to provide for the completion of the Troy & Greenfield railroad," and chapter 403 "An Act to provide for the management of the Hoosac Tunnel and the Troy & Greenfield railroad," etc., etc. These two acts are both approved on the same day, and I am of opinion that the words in chapter 403, section 1, clause 4, "they shall hold all moneys," etc., etc., can refer only to the appropriation in chapter 402.

To apply these words to the appropriation in chapter 365, would defeat the operation of that chapter, which it is perfectly clear the legislature did not intend to do.

I am, very respectfully,
Your obed't servant,

CHAS. R. TRAIN.

[F.]

OPINIONS

OF

HON. E. R. HOAR AND JAMES C. DAVIS, ESQ.,

AS TO THE LEGAL RIGHTS OF THE COMMONWEALTH IN REGARD TO CERTAIN RAILROADS CONNECTING WITH THE TROY & GREENFIELD RAILROAD.

[REFERRED TO IN THE REPORT, Pages 25, 26.]

BOSTON, 30 COURT STREET, December 31, 1874.

Hon. WILLIAM B. WASHBURN:

SIR :—I respectfully transmit to you herewith the opinion of Hon. E. R. Hoar upon the legal questions arising under the third and fifth clauses of the second section of the act by which the Boston, Hoosac Tunnel & Western Railroad Company was incorporated.

It is provided by Rev. Stat. c. 39, § 84, that "The Commonwealth may at any time during the continuance of the charter of any railroad corporation, after the expiration of twenty years from the opening of said railroad for use, purchase of the corporation the said railroad, and all the franchise, property, rights and privileges of the corporation, by paying them therefor such a sum as will reimburse them the amount of capital paid in, with a net profit thereon of ten per cent. per annum, from the time of the payment thereof by the stockholders to the time of such purchase." This provision is reënacted by Gen. Stat., c. 63, § 138, and Stat. 1874, c. 372, § 180.

Section 45 of Rev. Stat. c. 39 (Gen. Stat. c. 63, § 1;

Stat. 1874, c. 372, § 4), is as follows: — "All railroad companies that have been or that shall hereafter be incorporated, under the authority of this Commonwealth, shall have all the powers and privileges, and be subject to all the duties, liabilities and other provisions contained in this chapter respecting such corporations, so far as the same are consistent with their respective charters."

Stat. 1874, c. 372, § 181 (reënacting Stat. 1870, c. 325, § 2), provides that "The Commonwealth may at any time take and possess the road, franchise and other property of any railroad corporation after giving one year's notice in writing to such railroad corporation, and paying therefor such compensation as may be awarded by three commissioners, who shall be appointed by the supreme judicial court, and shall be duly sworn to appraise the same justly and fairly; said commissioners shall estimate and determine all damages sustained by any such railroad corporation by such taking of the road, franchise and other property thereof; and any such corporation aggrieved by the determination of said commissioners may have its damages assessed by a jury of the superior court in the county of Suffolk, in the same manner as is provided by law with respect to damages sustained by reason of the laying out of ways in the city of Boston."

The Troy & Boston Railroad Company is incorporated under the laws of the state of New York, and no rights have been at any time reserved or granted to the Commonwealth in respect to taking possession of its road, which extends from Troy to the boundary line of the states of New York and Vermont.

The Southern Vermont Railroad Company was incorporated under the laws of the state of Vermont. Its road, which is about six miles in length, extends from its junction with the Troy & Boston railroad, at the state line of New York, through the town of Pownal, in Vermont, to the state line of Massachusetts. This road is owned by the Commonwealth under foreclosure of a mortgage given by the Troy & Greenfield Railroad Company. It is subject to a perpetual lease to the Troy & Boston Railroad Company, and is operated by this company, which pays for it an annual rent of twelve thousand dollars. No right has been reserved to the Commonwealth to take possession of this road, except in the event of the failure of the lessees to pay the rent, and as it lies wholly without the jurisdiction of the Commonwealth, it cannot be taken under the right of eminent domain. The lease of the Southern Vermont railroad to the Troy & Boston Railroad Company, and the conveyances and legislation under which the Commonwealth derives its title to the road, may be found in Senate Doc. of 1862, No. 157, and Senate Doc. of 1874, No. 150, pp. 100–122.

The railroad extending from the state line of Vermont to the station at North Adams, about six and two-thirds miles in length, was constructed by the Troy & Greenfield Railroad Company, and is owned by the Commonwealth under foreclosure of its mortgages from that corporation. It is now operated by the Troy & Boston Railroad Company, under a lease from the Troy & Greenfield Railroad Company which is to continue until the completion of the Tunnel, and no longer. The lease is copied in Senate Doc. of 1874, No. 150, p. 78.

The railroad extending from the station at North Adams to the western end of the Tunnel, which is about two miles in length, has been lately constructed by the Commonwealth and is in its possession.

The Pittsfield & North Adams Railroad Corporation was incorporated in 1842, and its road, which is about twenty miles in length, and extends from Pittsfield to North Adams, has been open for use for more than twenty years. It is by its charter expressly made "subject to all the duties, liabilities and provisions contained in that part of the thirty-ninth chapter of the Revised Statutes which relates to railroad corporations." (Stat. 1842, chap. 69, sect. 1.) This road is leased to the Boston & Albany Railroad Company, and that corporation will be entitled to receive compensation for whatever damages it may sustain if the Commonwealth should take possession of the road.

The railroad extending from the eastern entrance of the Tunnel to Greenfield, which is about thirty miles in length, is owned by the Commonwealth, under foreclosure of its mortgages from the Troy & Greenfield Railroad Company, and has been mainly constructed by the Commonwealth. It is now operated by the Fitchburg Railroad Company, under a lease to the Fitchburg and Vermont & Massachusetts railroad companies, which will continue in force until the completion of the Tunnel, and no longer. A copy of this lease may be found in Senate Doc. of 1874, No. 150, p. 74.

The Vermont & Massachusetts Railroad Company was incorporated in 1844, and its road has been in use for more than twenty years. It is, by its charter, expressly made "subject to all the duties, liabilities and restrictions contained in that part of the thirty-ninth chapter of the Revised Statutes which relates to railroad corporations, and in the several statutes, subsequently passed, relating to such corporations, and in the forty-fourth chapter of the Revised Statutes." (Stat. 1844, chap. 134, sect. 1.) This road is now subject to a lease to the Fitchburg Railroad Company for the term of nine hundred and ninety-nine years, from January 1, 1874, and if the State should take possession of the road under its right of eminent domain, that corporation will be entitled to compensation for such damages as it may sustain from the cancellation of the lease.

The charter of the Fitchburg Railroad Company contains a provision similar to that quoted from the act incorporating the Vermont & Massachusetts Railroad Company. (Stat. 1842, chap. 84, sect. 1.)

The Massachusetts Central Railroad Company was incorporated in 1869, and its charter provides that it shall be "subject to all the restrictions, duties and liabilities set forth in the general laws which now are, or may hereafter be, in force, relating to railroad corporations." (Stat. 1869, chap. 260, sect. 1.)

The twenty per cent. traffic contract of the Vermont & Massachusetts, Fitchburg, and Troy & Boston railroad companies with the Commonwealth, executed in February, 1863, is set forth in Senate Doc. of 1874, No. 150, p. 123. It was ratified by the legislature by Stat. of 1863, chap. 214. sect. 6.

I am very respectfully yours,

JAMES C. DAVIS.

OPINION.

My opinion is asked by the "Boston, Hoosac Tunnel & Western Railroad Company," upon the legal questions arising under the third and fifth clauses of the second section of Stat. 1874, chapter 403.

I. Under the Third Clause.

1. The Commonwealth has reserved to itself the legal right of taking possession of each of the railroads incorporated by it, after the expiration of twenty years from the opening of the railroad for use, by paying to the railroad company such a sum therefor as will reimburse the company the amount of capital paid in, with a net profit thereon of ten per cent. per annum from the time of the payment thereof by the stockholders, to the time of such purchase. The process would include only the ascertainment of the amount to be paid, for which the reports required of the companies afford the requisite material, and the making of the payment. (Rev. Stat. c. 39, § 84; Gen. Stat. c. 63, § 138; Rev. Stat. c. 39, § 45; Stat. 1842, c. 84, § 1; Stat. 1844, c. 134, § 1; Stat. 1874, c. 372, § 180.)

As the election of the Commonwealth to purchase a railroad under this reserved right must be made through some act of legislation, it would be competent and proper in the same act to provide for the doing of whatever would be necessary to complete the purchase.

2. By Stat. 1870, c. 325, § 2, and Stat. 1874, c, 372, § 181, the right to take the railroad, franchise and property of any railroad corporation, is expressly reserved to the Commonwealth, upon giving one year's notice in writing, and upon payment of the value of what is thus taken, as ascertained by commissioners appointed by the supreme court, and, in case the corporation is dissatisfied, with the right to an assessment by a jury.

It will be observed that this provision of law, like the one before referred to, can have no practical effect without further legislation. It does not determine who shall give the notice in writing, or apply for the appointment of commissioners; nor does it become applicable to any particular railroad corporation without a new exercise of legislative will, and a provision for the money to pay for the franchise and property taken. I fail to see that it is of any force or effect, except as giving notice to railroad corporations of what may hereafter befall them.

3. But the more important questions I take to be, whether the two provisions are in any respect inconsistent with each other?—or whether either is in the nature of a contract with the railroad companies, which can impair or restrict the exercise of the right of eminent domain? I am very clearly of opinion that there is no inconsistency between them, and that neither affects in any respect the right of the State to take the franchise and property of a railroad corporation, whenever the legislature finds that a public exigency requires, upon making just compensation for the franchise and property taken.

The reservation of the right to take the railroad at the end of twenty years, on paying its capital and a profit thereon of ten per cent. per annum, is a stipulation in favor of the Commonwealth, by fixing an upward limit of price at which the property may be taken, although its value might greatly exceed that limit. It is perfectly consistent with this that the property should be taken at any time that the public good requires, on payment of its full value. Nor can the fact that the legislatures of 1870 and 1874 have notified the railroads that the Commonwealth may take their property at its ascertained value upon giving a year's notice in writing, prevent any subsequent legislature from enacting that it may be taken on a notice of a month, a day, or without any notice whatever. The taking by eminent domain, from a public exigency, for just compensation, impairs the obligation of no contract, because it recognizes the complete and entire title of the corporation to its franchise and property, and pays for it as for the property of any individual.

The principles of constitutional law upon which this view rests are so fully and clearly stated by our supreme judicial court in the case of Central Bridge Corporation *v.* Lowell (4 Gray, 474), and are so completely sustained by the decisions of the supreme court of the United States there cited, that any further citation of authorities would be superfluous. That case, as it seems to me, settles the law for this Commonwealth.

II. Under the Fifth Clause.

I am not aware of any other contract to which this clause refers than that entered into in February, 1863, by the Troy & Boston Railroad Company, the Fitchburg Railroad Company, and the Vermont & Massachusetts Railroad Company, and approved, ratified and confirmed by act of the legislature, passed April 29, 1863.

By this contract, these railroad corporations, in consideration that the Commonwealth would complete the Hoosac Tunnel and the Troy & Greenfield railroad, agreed to pay to the Commonwealth one-fifth of their gross earnings upon such business as should pass over any part of the said Troy & Greenfield railroad.

I can see no reason to doubt the validity and binding effect of this contract upon the several corporations named. Its purport is clear and obvious, and seems to need no explanation. Its value may depend upon the question, whether the railroads can afford to do the business referred to upon such terms. If they cannot, and the contract is so improvident that it would be ruinous or greatly injurious to them, as there is nothing in the law or the contract to limit the price which they shall charge for the business, they would be likely to protect themselves by fixing such rates of fares and freights as would result in doing very little business of such an unprofitable kind. The value of a contract thus limited would not probably be great, and it would undoubtedly not be sound policy for the Commonwealth to adhere to a contract which should interfere with the use of the Tunnel to the fullest extent upon reasonably remunerative terms.

E. R. HOAR.

Boston, December 28, 1874.

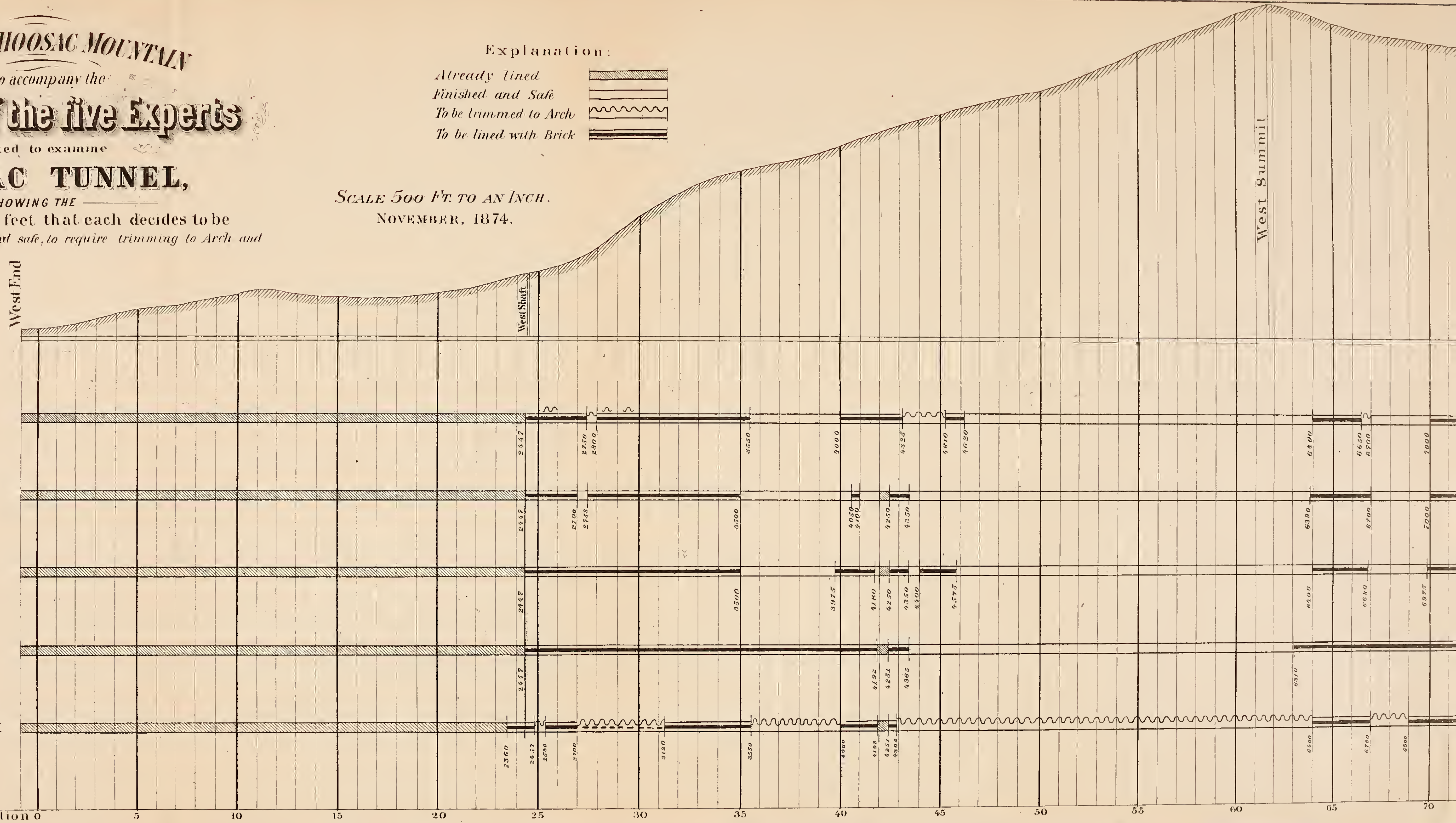
Pockets for maps
2-180

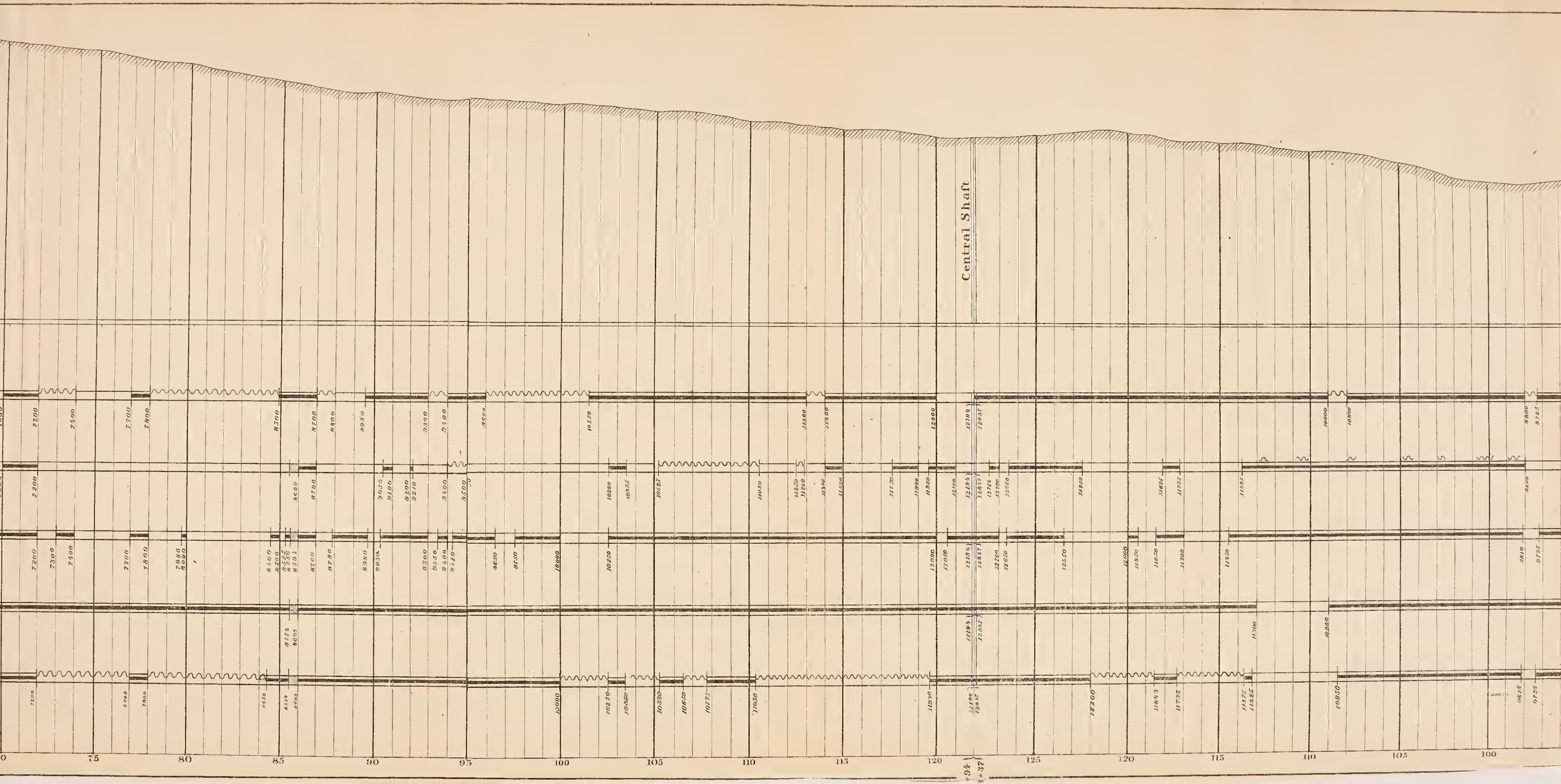
PROFILE OF HOOSAC MOUNTAIN
made to accompany the
Reports of the five Experts
appointed to examine
HOOSAC TUNNEL,
SHOWING THE
Number of lineal feet that each decides to be *already lined, to be finished and safe, to require trimming to Arch and to require lining with Brick.*

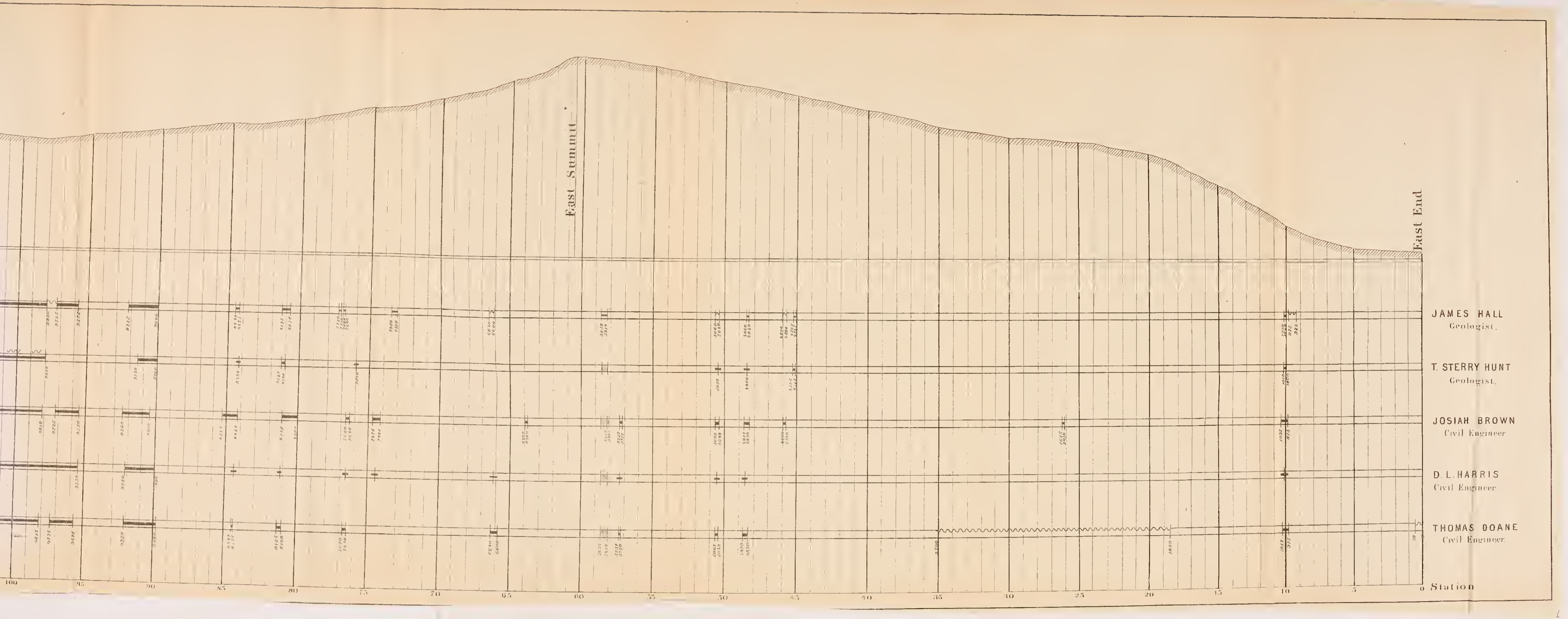
Explanation:

Already lined	▨
Finished and Safe	═
To be trimmed to Arch	〰
To be lined with Brick	▬

SCALE 500 FT. TO AN INCH.
NOVEMBER, 1874.

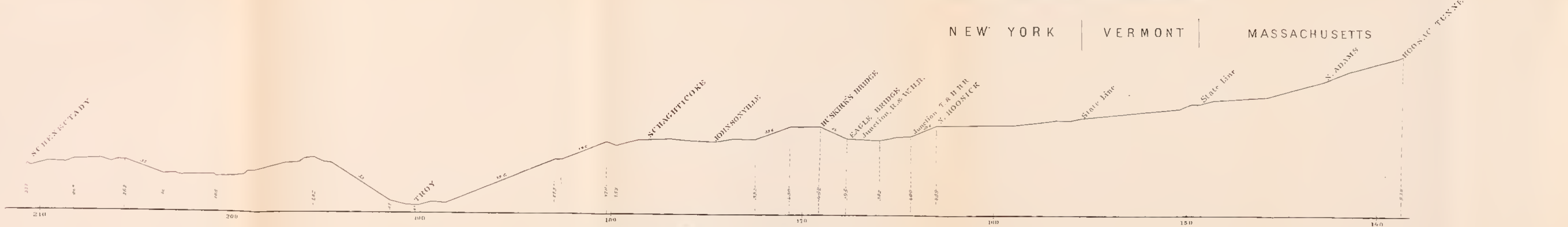



Central Shaft
3+37

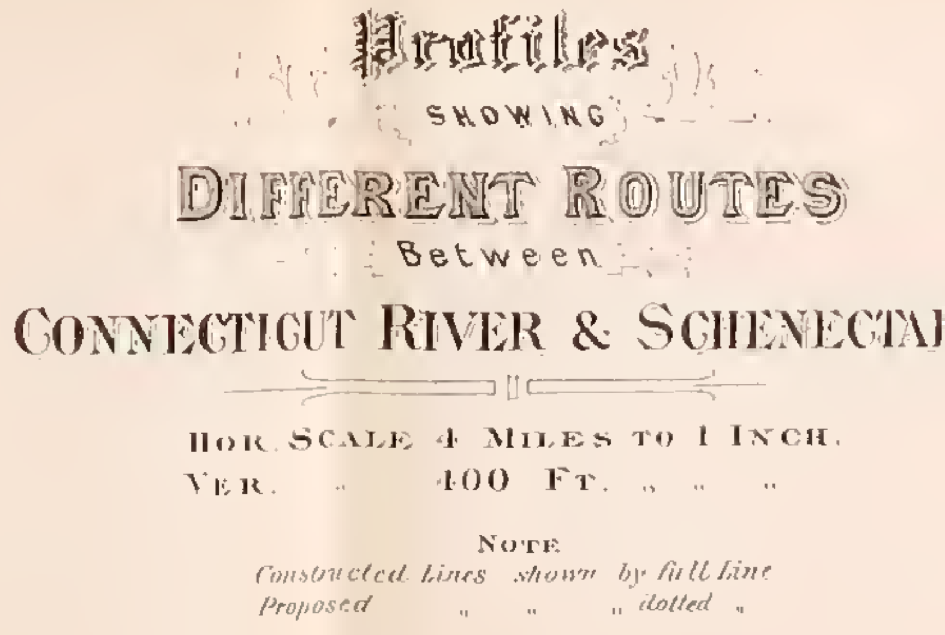

East Summit
East End
JAMES HALL
Geologist.
T. STERRY HUNT
Geologist.
JOSIAH BROWN
Civil Engineer
D. L. HARRIS
Civil Engineer
THOMAS DOANE
Civil Engineer
Station

CONNECTICUT RIVER TO SCHENECTADY
VIA BOSTON & ALBANY R.R.

CONNECTICUT RIVER TO SCHENECTADY
VIA HOOSAC TUNNEL
(Proposed Low Grade Route to Schenectady)



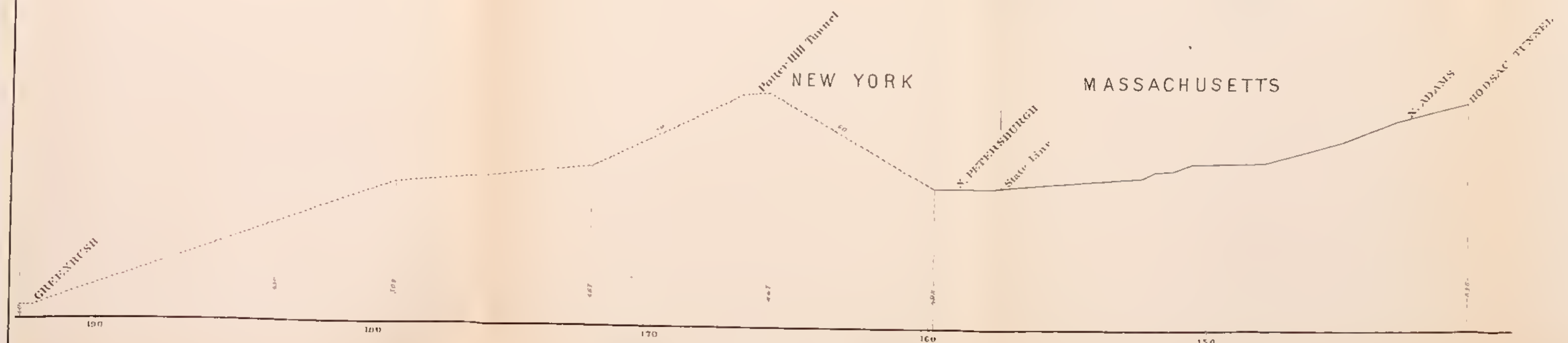
HOOSAC TUNNEL TO ALBANY
VIA TROY & BOSTON & N.Y. CENTRAL R.R.



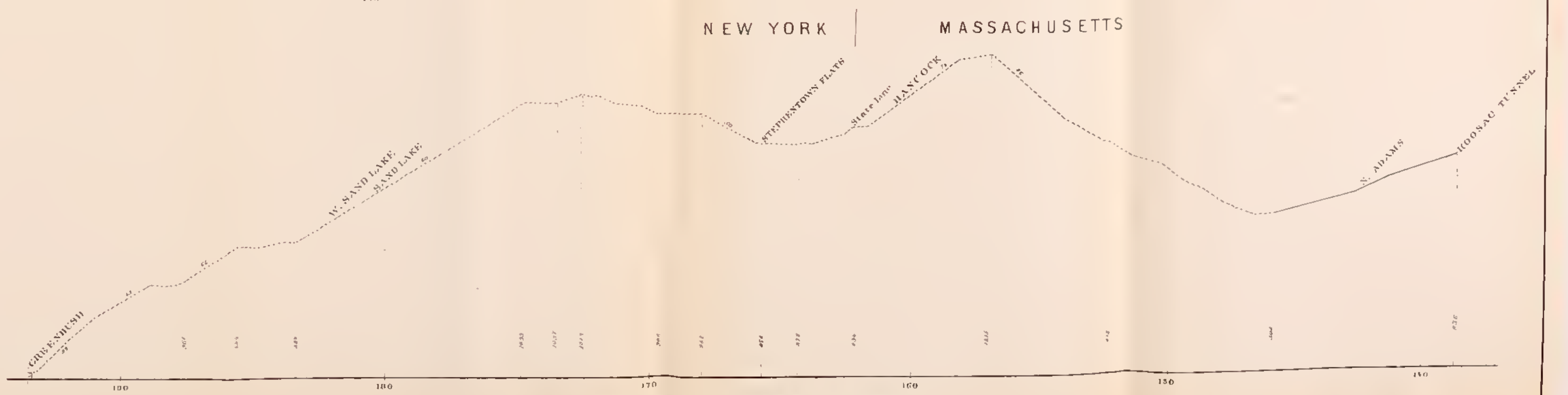
Profiles
SHOWING
DIFFERENT ROUTES
Between
CONNECTICUT RIVER & SCHENECTADY.

HOR. SCALE 4 MILES TO 1 INCH.
VER. " 400 FT. " " "

NOTE
Constructed Lines shown by full line
Proposed " " " dotted "



HOOSAC TUNNEL TO ALBANY
VIA POTTER HILL
(Stevens Route)



HOOSAC TUNNEL TO ALBANY
VIA HANCOCK & STEPHENTOWN
(Stephentown Route)

PROFILE OF

HOOSAC MOUNTAIN

made to accompany

THOMAS DOANE'S

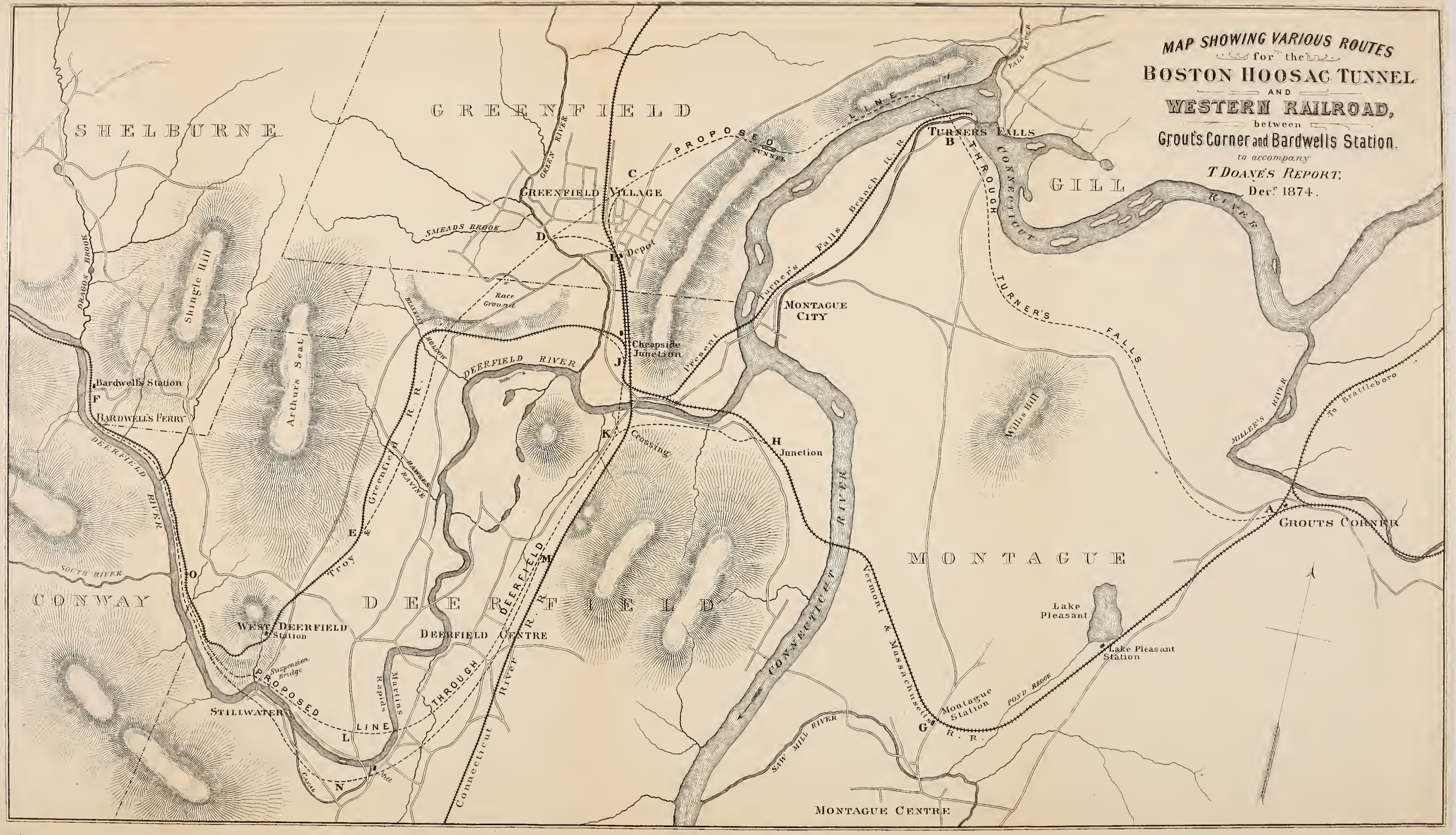
Report Oct. 13th 1874.

SCALE 500 FT. TO AN INCH

EXPLANATION:

Inclined single lines indicate the Stratification of the Rock
" double lines " " injected veins
Tunnel driven by Nitro Glycerine
" " " Common Powder
Heads lined
Finished and Safe
To be trimmed to Arch
" lined with Brick

To be trimmed to Arch
To be lined
Already lined
Longitudinal Seams
To be lined
To be arched on one side
To be trimmed to Arch
Probably made safe
by trimming to Arch
To be lined from Central Shaft to west
Central Shaft
Longitudinal Seams
Probably require lining
Probably made safe
by trimming to Arch
To be lined. Already Enlarged
To be trimmed to Arch
To be lined now being Enlarged
Finished and Safe
Full of Longitudinal Seams
To be lined
Longitudinal Seams
To be lined
Now being Enlarged for lining
Finished and Safe
To be lined
Finished and Safe
Longitudinal Seams
To be lined
Finished and Safe
Finished and Safe
Rotten seam To be lined
Finished and Safe
To be lined
Finished and Safe
To be lined
Finished and Safe
Already lined
Finished and Safe
To be lined
Finished and Safe
To be lined
Finished and Safe
To be lined
Finished and Safe
To be trimmed to Arch
Finished and Safe
To be lined
Finished and Safe
To be trimmed to Arch
Bed of Cold River
East Summit
Central Shaft
East Portal
Glycerine roof
Glycerine roof
Glycerine roof
Powder roof
Bottom heading
Bottom heading



MAP SHOWING VARIOUS ROUTES
for the
BOSTON HOOSAC TUNNEL
AND
WESTERN RAILROAD,
between
Grout's Corner and Bardwells Station.
to accompany
T. DOANE'S REPORT,
Dec.r 1874.

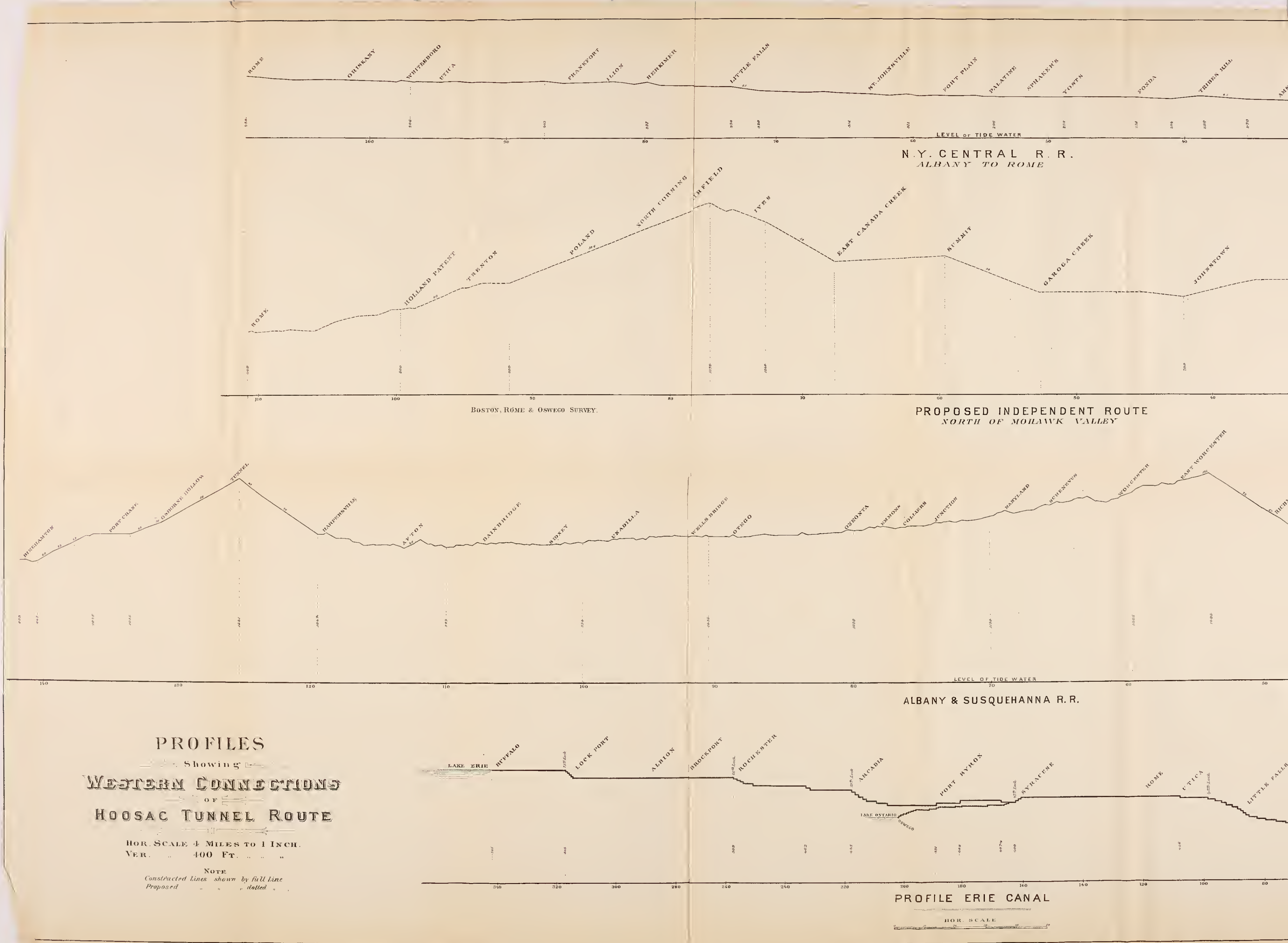
TABLE OF DISTANCES FROM SCHENECTADY TO VARIOUS WESTERN POINTS, VIA NEW YORK CENTRAL RAILROAD AND ERIE RAILWAY LINES.

[PREPARED FOR USE OF BOSTON, HOOSAC TUNNEL & WESTERN RAILROAD COMPANY, BY DIRECTION OF ERIE RAILWAY COMPANY.]

DESTINATION.	ROUTE.	Distance.	ROUTE.	Distance.	ROUTE.	Distance.	ROUTE.	Distance.	ROUTE.	Distance.	ROUTE.	Distance.	N. Y. Central Railroad.	Erie Railway.	Boston, via Schenectady and N. Y. C. R. R.	Boston, via Schenectady and Erie Railway.	Boston, via B. & A. R. R. and N. Y. C. R. R.
BUFFALO,	N. Y. C. R. R., Schenectady — Buffalo,	280											280		485		498
	A. & S. R. R., Schenectady — Binghamton,	130	Erie Railway, Binghamton — Buffalo,	208										338		543	
DETROIT, via G. W. R.,	N. Y. C. R. R., Schenectady — Susp. Bridge,	287			G. W. R. R., Susp. Bridge — Detroit,	229							516		721		734
	A. & S. R. R., Schenectady — Binghamton,	130	Erie Railway, Binghamton — Susp. Bridge,	229½	" "	229								588½		793	
CHICAGO,	N. Y. C R. R., Schenectady — Susp. Bridge,	287			G. W. R. R., Susp. Bridge — Detroit,	229	M. C. R. R., Detroit — Chicago,	284					800		1,005		1,018
	A. & S. R. R., Schenectady — Binghamton,	130	Erie Railway, Binghamton — Susp. Bridge,	229½	" "	229	" "	284						872½		1,077½	
CLEVELAND, via L. S. & M. S. R.,	N. Y. C. R. R., Schenectady — Buffalo,	280			L. S. & M. S. R., Buffalo — Cleveland,	183							463		668		681
	A. & S. R. R., Schenectady — Binghamton,	130	Erie Railway, Binghamton — Salamanca,	199	A. & G. W. R. R., Salamanca — Cleveland,	213								542		747	
TOLEDO, via L. S. & M. S. R.,	N. Y. C. R. R., Schenectady — Buffalo,	280			L. S. & M. S. R., Buffalo — Toledo,	296							576		781		794
	A. & S. R. R., Schenectady — Binghamton,	130	Erie Railway, Binghamton — Buffalo,	208	" "	296								634		839	
CHICAGO, via L. S. & M. S. R.,	N. Y. C. R. R., Schenectady — Buffalo,	280			L. S. & M. S. R., Buffalo — Chicago,	539							819		1,024		1,037
	A. & S. R. R., Schenectady — Binghamton,	130	Erie Railway, Binghamton — Buffalo,	208	" "	539								877		1,082	
COLUMBUS,	N. Y. C. R. R., Schenectady — Buffalo,	280			L. S. & M. S. R., Buffalo — Cleveland,	183	C. C. C. & I., Cleveland — Columbus,	138					601		806		819
	A. & S. R. R., Schenectady — Binghamton,	130	Erie Railway, Binghamton — Salamanca,	199	A. & G. W. R. R., Salamanca — Galiou,	284	C. C. C. & I., Galiou — Columbus,	58						671		876	
CINCINNATI,	N. Y. C. R. R., Schenectady — Buffalo,	280			L. S. & M. S. R., Buffalo — Cleveland,	183	C. C. C. & I., Cleveland — Cincinnati,	244					707		912		925
	A. & S. R. R., Schenectady — Binghamton,	130	Erie Railway, Binghamton — Salamanca,	199	A. & G. W. R. R., Salamanca — Dayton,	389	C. H. & D., Daytou — Cincinnati,	60						778		983	
LOUISVILLE, via Cincinnati,	N. Y. C. R. R., Schenectady — Buffalo,	280			L. S. & M. S. R., Buffalo — Cleveland,	183	C. C. C. & I., Cleveland — Cincinnati,	244	L. C. & L. R., Cincinnati — Louisville,	110			817		1,022		1,035
	A. & S. R. R., Schenectady — Binghamton,	130	Erie Railway, Binghamton — Salamanca,	199	A. & G. W. R. R., Salamanca — Dayton,	389	C. H. & D., Dayton — Cincinnati,	60	" "	110				888		1,093	
ST. LOUIS, via Cincinnati,	N. Y. C. R. R., Schenectady — Buffalo,	280			L. S. & M. S. R., Buffalo — Cleveland,	183	C. C. C. & I., Cleveland — Cincinnati,	244	O. & M. R., Cincinnati — St. Louis,	340			1,047		1,252		1,265
	A. & S. R. R., Schenectady — Binghamton,	130	Erie Railway, Binghamton — Salamanca,	199	A. & G. W. R. R., Salamanca — Dayton,	389	C. H. & D., Dayton — Cincinnati,	60	" "	340				1,118		1,323	
INDIANAPOLIS,	N. Y. C. R. R., Schenectady — Buffalo,	280			L. S. & M. S. R., Buffalo — Cleveland,	183	C. C. C. & I., Cleveland — Indianapolis,	282					745		950		963
	A. & S. R. R., Schenectady — Binghamton,	130	Erie Railway, Binghamton — Salamanca,	199	A. & G. W. R. R., Salamanca — Galion,	284	C. C. C. & I., Galion — Indianapolis,	202						815		1,020	
LOUISVILLE, via Indianapolis,	N. Y. C. R R., Schenectady — Buffalo,	280			L. S. & M. S. R., Buffalo — Cleveland,	183	C. C. C. & I., Cleveland — Indianapolis,	282	J. M. & I. R., Indianapolis — Louisville,	110			855		1,060		1,073
	A. & S. R. R., Schenectady — Binghamton,	130	Erie Railway, Binghamton — Salamanca,	199	A. & G. W. R R., Salamanca — Galion,	284	C. C. C. & I., Galion — Indianapolis,	202	" "	110				925		1,130	
ST. LOUIS, via Indianapolis,	N. Y. C. R. R., Schenectady — Buffalo,	280			L. S. & M S. R., Buffalo — Cleveland,	183	C. C. C. & I., Cleveland — Indianapolis,	282	St. L. V. T. H. & I. R., Indianapolis — St. Louis,	238			983		1,188		1,201
	A & S R R, Schenectady — Binghamton,	130	Erie Railway, Binghamton — Salamanca,	199	A. & G. W. R. R., Salamanca — Galion,	284	C. C. C. & I., Galion — Indianapolis,	202	" "	238				1,053		1,258	
CHICAGO, via B. & O. R. R. Extension,	A. & S R. R., Schenectady — Binghamton,	130	Erie Railway, Binghamton — Salamanca,	199	A. & G. W. R. R., Salamanca — Ashland,	252	Ashland — Chicago Junction,	23	B. & O. R. R., Chicago Junction — Chicago,	268				872		1,077	
TOLEDO, via C. S. R.,	N. Y. C. R. R., Schenectady — Inter'l Bridge,	286			C. S. R., Inter'l Bridge — Toledo,	269							555		760		773
	A. & S. R. R., Schenectady — Binghamton,	130	Erie Railway, Binghamton — Inter'l B'dge,	216	" "	269								615		820	
LOGANSPORT,	N. Y. C. R R., Schenectady — Inter'l Bridge,	286			C. S. R., Inter'l Bridge — Toledo,	269	T. W. & W., Toledo — Logansport,	166					721		926		939
	A. & S. R. R, Schenectady — Binghamton,	130	Erie Railway, Binghamton — Inter'l B'dge,	216	" "	269	" "	166						781		986	
PEORIA,	N. Y. C. R. R., Schenectady — Inter'l Bridge,	286			C. S. R, Inter'l Bridge — Toledo,	269	T. W. & W., Toledo — Logansport,	166	P. C. & St. L. R., Logansport — State Line,	61	T. P. & W., State Line — Peoria,	111	893		1,098		1,111
	A. & S R. R, Schenectady — Binghamton,	130	Erie Railway, Binghamton — Inter'l B'dge,	216	" "	269	" "	166	" "	61	" "	111		953		1,158	

Average in favor of N. Y. C. R. R. over Erie Railway, from Schenectady, . . . 67

Average in favor of B. & A. R. R. and N. Y. C. R. R. over Hoosac Tunnel and Erie Railway, from Boston, . . . 48



PROFILES

Showing

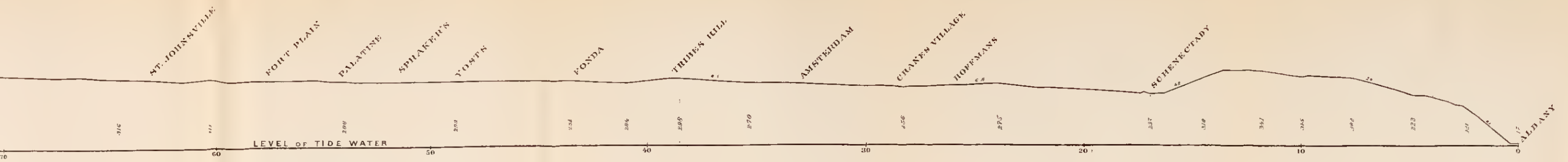
WESTERN CONNECTIONS

OF

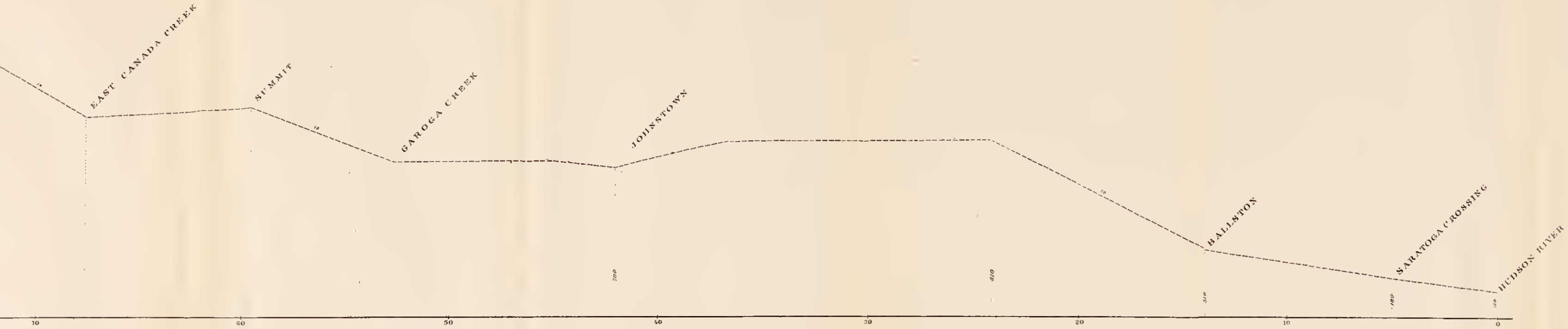
HOOSAC TUNNEL ROUTE

HOR. SCALE 4 MILES TO 1 INCH.
VER. " 400 FT. " " "

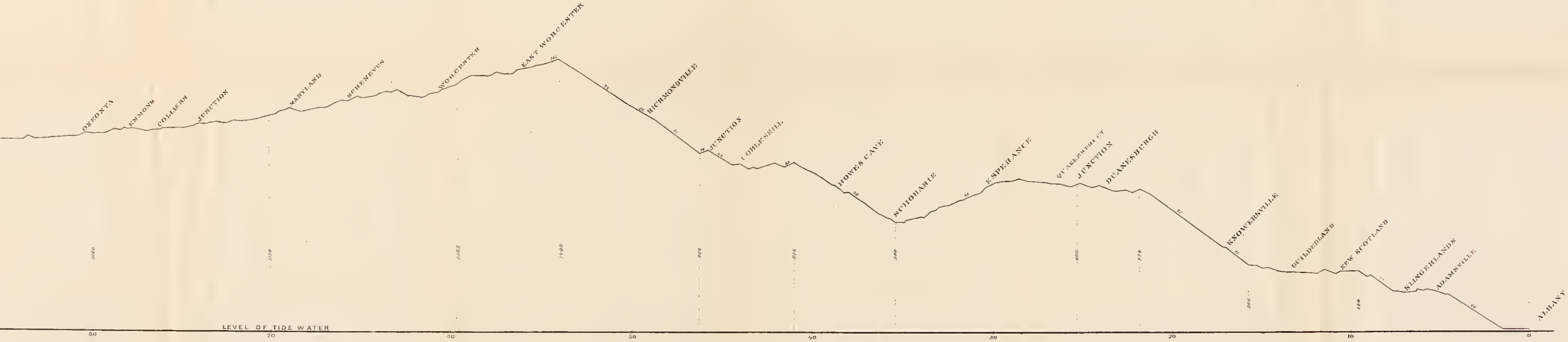
NOTE
Constructed Lines shown by full line
Proposed " " " dotted "



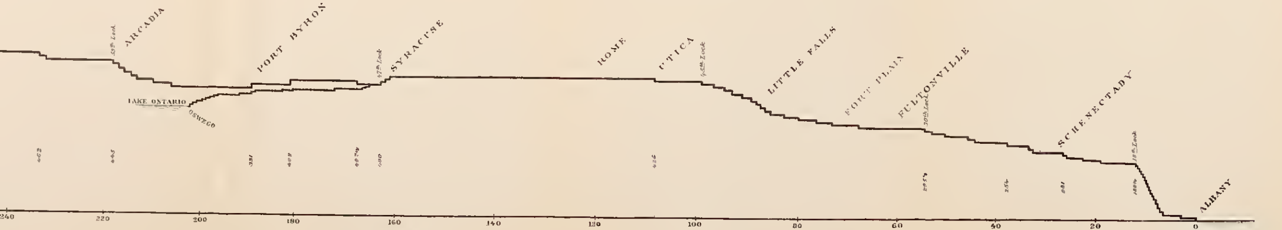
N.Y. CENTRAL R. R.
ALBANY TO ROME



PROPOSED INDEPENDENT ROUTE
NORTH OF MOHAWK VALLEY

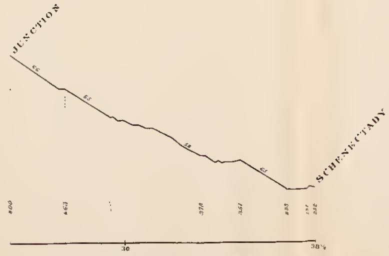


ALBANY & SUSQUEHANNA R.R.

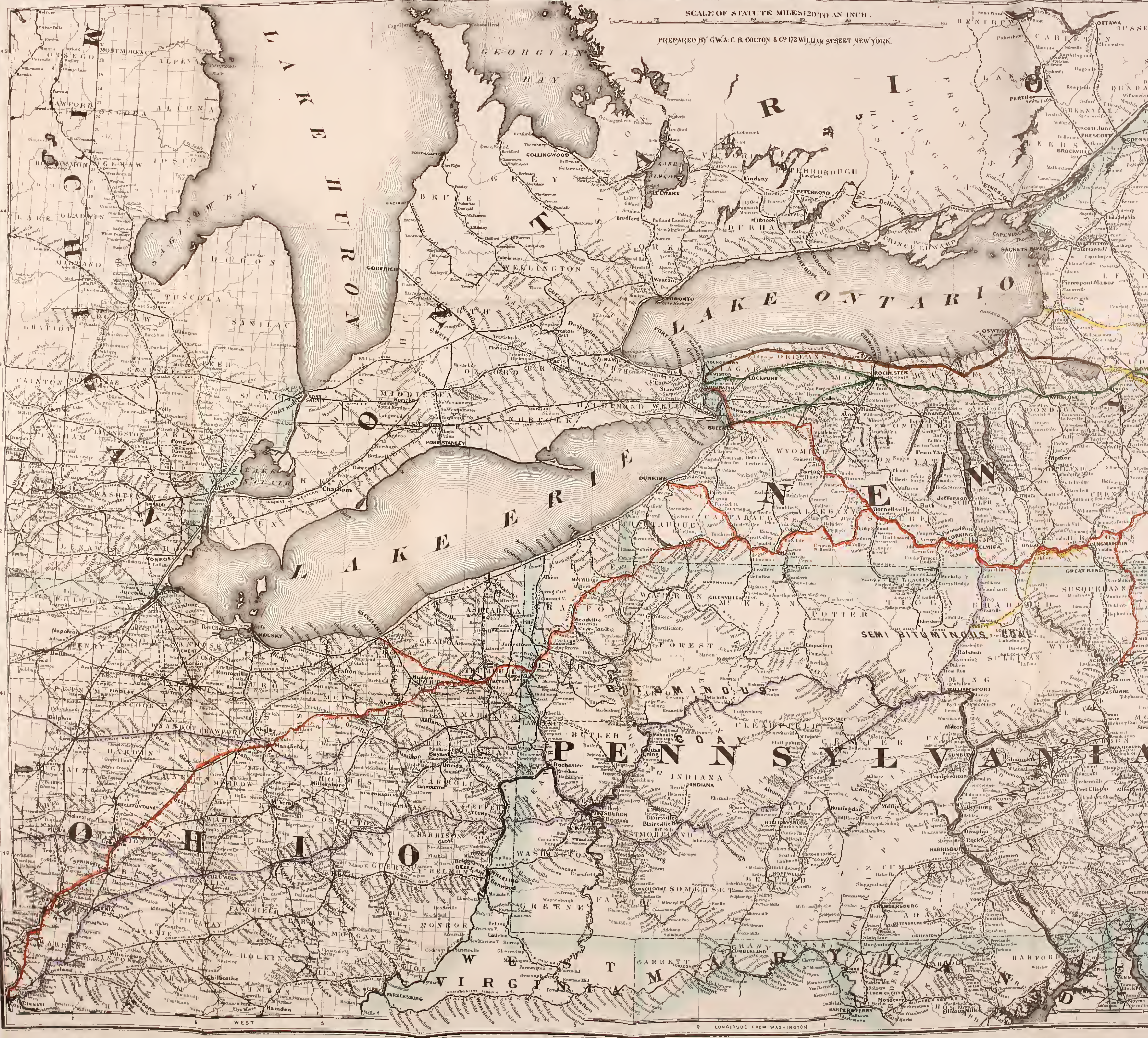


PROFILE ERIE CANAL

HOR. SCALE

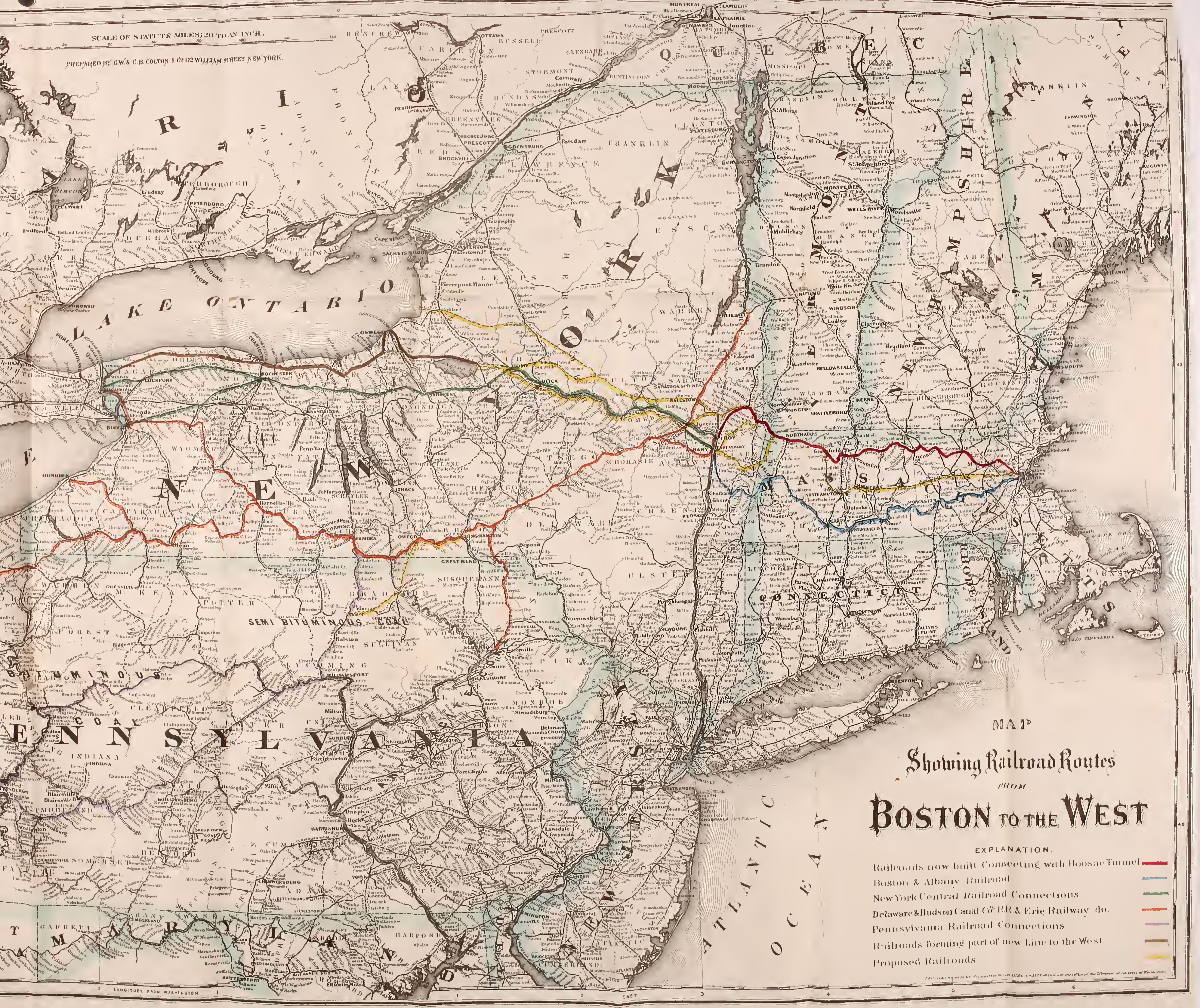


ALBANY & SUSQUEHANNA R. R.
JUNCTION TO SCHENECTADY



SCALE OF STATUTE MILES; 20 TO AN INCH.

PREPARED BY G.W. & C.B. COLTON & Co 172 WILLIAM STREET NEW YORK.



MAP
Showing Railroad Routes
FROM
BOSTON TO THE WEST

EXPLANATION.

Railroads now built Connecting with Hoosac Tunnel	🟥
Boston & Albany Railroad	🟦
New York Central Railroad Connections	🟩
Delaware & Hudson Canal Co.'s R.R. & Erie Railway do.	🟧
Pennsylvania Railroad Connections	🟪
Railroads forming part of new Line to the West	🟫
Proposed Railroads	🟨

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